

**AN ENQUIRY INTO 'THE AGUE' IN SCOTLAND**

**by**

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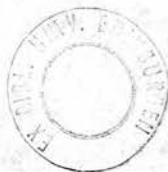
**Thesis submitted for the degree of**

**DOCTOR OF MEDICINE**

**at**

**UNIVERSITY OF EDINBURGH**

**1978**



Perhaps the greatest source of information about living in Scotland in the eighteenth century is to be found in the Statistical Account. This was written for each parish in the last decade of the century.

The term 'ague' is used with regard to some acute fever which regularly recurred in several parishes. This term has been translated into the word 'malaria' by many modern authorities who have thus stated that malaria was the 'scourge of Scotland'.

This thesis sets out to examine the probability of this being true. In doing so the background of the living conditions in town and country, and in particular the changes in farming practice have been set out and scrutinised. Malarial vectors and parasites and the conditions necessary for their development have been noted.

The essential elements necessary to start and maintain a cycle of malarial transference are set out and examined against the aforesaid background with especial reference to the carriers of the disease. Vivax malaria is described in modern terms and contrasted with the ague that was reported in textbooks, in clinical notes and in hospital registers.

The whole is summarised and doubt is expressed on the correctness of the view that 'ague' was so frequently 'malaria' that the two words should be synonymous. In addition a chapter has been devoted to differential diagnosis for the term 'ague'.

'And I hereby declare and affirm that this thesis is entirely my own work and composition.'

Michael Finlay.



# CONTENTS

An Introduction to the subject.

1. Introductory essay.	P. 5
2. Etymology and definition of terms.	27.
Geographical distribution of ague in Scotland.	
3. Malaria - the parasites.	42.
4. Malaria - the vectors.	52.
5. Environmental factors affecting vectors - land reclamation.	64.
6. Environmental factors affecting vectors - improved animal husbandry.	75.
7. Environmental factors affecting parasites and vectors - temperature.	93.
8. Malaria - the carriers.	113.
9. Treatment of agues. Modern description of malaria. Seven- teenth, eighteenth and nineteenth century descriptions of agues.	129.
10. Hospital records - admissions with ague and intermitting fever.	146.
11. Ague, the farm labourers disease. Possible vectors and differential diagnosis.	162.
12. Summary.	175.
13. Appendices I, II, III, IV and V.	181.
Bibliography.	202.

### ACKNOWLEDGEMENTS

I suspect that however much, and however often one writes essays and articles, theses and books, the author will be greatly indebted to several persons. In this particular instance his thanks go firstly to Margaret Blennerhassett, who has not only typed out all these words, but has wondrously deciphered the script with which she was provided.

The author's immeasurable thanks is given also to so many library workers who have metaphorically held his hand, and actually guided his footsteps: To Miss Ferguson of the Royal College of Physicians of Edinburgh and her colleagues: Miss Alison Harvey Wood, Mrs Cox and Mr Patrick Cadell of the National Library of Scotland: Miss Bell and all her colleagues at the University of Edinburgh Central Medical Library and the staff of the main University Library: to the librarians of the Edinburgh Public Libraries: the Bodleian Library, and the Wellcome Institute Library: to Mr Hearst of the Meteorological Office Library in Edinburgh: Mrs Eaves-Walton, archivist to Edinburgh Royal Infirmary: Mr Bates and Miss Hunter of the Scottish Record Office: to Mr Boag of the Scottish United Services Museum Edinburgh, and to Dr Andrew Pearson of Southampton University: to Professor Russell Lumsden of the London School of Tropical Medicine and Hygiene and to

Dr H.A. van Seventer of the University of Amsterdam: and, at the time, to the late Mrs McCracken of Kelso who most generously gave her manuscripts to the Scottish Record Office: and to Dr A.H.B. Masson, my mentor.

As importantly his thanks is given to all those friends and acquaintances at whom he has talked about the ague, and perhaps especially his wife and long-suffering daughter Rosalind.

And finally to an eminent, anonymous and most encouraging friend, who has not only listened and commented, but has provided glasses of sherry at the same time.



## INTRODUCTION

This thesis sets out to show that it is not reasonable to use the word 'malaria' synonymously with 'ague' or 'intermitting fever'. This is especially the case when it is applied to various morbid conditions which regularly recurred in Scotland in the eighteenth century.

The problem was noticed when, at the opening of an historical exhibition in Edinburgh an accompanying booklet about the city's life at the end of the eighteenth century stated that 'people drifted to the towns to be met with insanitary conditions and raging fevers, and the sweeping away of whole families by typhus and malaria'. (1)

The sources of that writer's information were found and checked, whereupon it was noted that several authoritative works by eminent authors stated that ague had been rampant in Scotland during that century. However in their accounts all of them substituted the word 'malaria' for the expressions 'ague and intermittent fever'!

For example Ritchie wrote, 'Of the ailments which laid hold of our forefathers a couple of centuries ago, none was more prevalent or more persistent in its attacks and effects than ague ... intermittent fever or malaria as it is variously termed'. (2)



Brotherston wrote, 'Ague or malaria was one of the scourges of Scotland'. (3)

Smout wrote, 'Malaria had been present in Scotland and suddenly died out between 1780 and 1800 again for no known reason. Though seldom a fatal disease in itself, it was a very debilitating one and contributed to a high death rate from other causes, especially among children.' (4)

The thesis is therefore that, as applied to Scotland in the eighteenth century, ague should not, invariably, probably not even frequently, be synonymous with malaria.

It is therefore necessary to examine what is meant by the words 'ague', 'intermitting fever' and 'malaria'. Thereafter, having assessed the evidence in favour of the thesis and found that it is probably true, it is desirable to suggest an alternative interpretation for the word 'ague' in the circumstances of which this is written.

In the following chapters, therefore, the text should be taken to refer to Scotland during the eighteenth century unless it is specifically stated otherwise.

Most of the temperature figures quoted in this work were recorded on the Fahrenheit scale. Despite the recent official change to Centigrade, the former scale is used in this work in order to avoid constant interpolation of figures in the other series. This has entailed the

conversion of Centigrade figures when they appear in quoted original extracts.

Comments from the minister of the parish of Borgue writing for the Statistical Account in 1794 deserve to be the last words of this introduction.(5) 'Agues formerly prevailed very much but not one instance for the last nine or ten years. Marsh miasma is assigned as the remote cause of intermittent fevers. And when such diseases become less prevalent it is very natural to suppose that the drainage of marshes and mosses must be the occasion of it. But in this district no mosses nor marshes have been drained of any consequence for many years past, nor has any other remarkable alteration happened to affect the salubrity of the air except what may be supposed to arise from the superior cultivation of the ground. Hence we may conclude that cultivation of the ground will in various ways contribute to remove the cause of agues and other febrile diseases. These remarks may, it is hoped, prove useful to excite further enquiry into a matter which is so peculiarly interesting.'

1. Leishman, M. (1975) No 7 Charlotte Square, Edinburgh.  
10 National Trust for Scotland Edinburgh.
2. Ritchie, J. (1920) Influence of Man on Animal Life in  
Scotland 508 Cambridge University Press.
3. Brotherston, J.H.F. (1952) The early public health  
movement in Scotland 25 London.
4. Smout, T.C. (1969) A History of the Scottish People  
1560-1830 271 London.
5. Sinclair, J. (1791-1799) Statistical Account of  
Scotland II 34 Edinburgh.



## CHAPTER 1

### An Introductory Essay \*

It is certainly the case that history is the recording of past facts. It has however a wider connotation, and, reasonably, includes comment on the events which subsequently occurred, and were apparently related to the facts. It also may include speculation on what might have been if different interpretations had been made. But it must not confuse facts with rumours. Folklore is not necessarily history in the most proper sense. Nevertheless rumour, folklore and sentiment, though uninformed observations, are all stimuli to enquiry. Moreover, the enquiry may happily uncover the facts, which rightly or wrongly interpreted gave rise to the rumour, which in its turn may have become part of, if not the dogma, at least the current expression of language or thinking of the day.

It is a perfect example of this notion that that which is now called malaria was thus labelled because it was caused by the mala-aria and the miasmata and marsh gases. Indeed since the days of Hippocrates this had been the accepted dogma. Furthermore, even 2,000 years ago it had been suggested that mosquitoes might play some part in its transmission.

### Ague in Scotland

There can be no doubt that there were many instances

\* No references are given in this chapter for all are reiterated. Each one appears in the list at the end of the appropriate chapter hereafter.



of ague and intermitting fever throughout Great Britain. In Scotland it is said that those complaints were prevalent in many of those parishes which are situated on the east coast and along the lowest courses and estuaries of the rivers Tay, Forth and Tweed. It is also stated, though less convincingly, that these illnesses were unknown in Scotland before the Union of the two Kingdoms at the beginning of the eighteenth century. Furthermore, it is alleged that they had died out by the end of the century because the drainage of the lands had thus banished them, for it was thought that the sources of the miasmata which caused them had been demolished. Thus, years later, when the word malaria had been introduced into the vocabulary, ague and intermitting fevers were written of as being synonymous with malaria.

#### Mala-aria

This 'mala-aria' was an expression used by the Italians who lived in the area of the Roman Campagna and Pontine marshes where it is known that disease due to the plasmodia existed until the second quarter of the twentieth century. Hence, lacking that accurate knowledge which alone makes precise diagnosis possible, the mala-aria of the Italian marshland agues became the malaria of all the agues in England and Scotland.

#### Accurate diagnosis

About 100 years ago it was proved beyond any reasonable doubt that malaria was due to the invasion of the human body by one of the plasmodia. Furthermore it was observed

and this time proved, that these organisms were transferred from one human to another by a vector mosquito. It was also noticed, particularly, that the only mosquitoes responsible were the females of some of the species of *Anopheles*.

By the last decade of the nineteenth century the study of microbiology had prospered with the aid of better microscopes, and the newer techniques of dye-staining and methodical culture. Thus accurate diagnoses could be made. Thereafter it should not have been said that someone had malaria unless plasmodia had been found in his blood.

### Cinchona

However, even before this time the bark of the tree *Cinchona officinalis* had been recognised as having a beneficial effect on ague. It is a measure of the surmised prevalence of ague throughout the world, even 300 years ago, that the demand for cinchona soon outstripped the supply. And it is a measure of the effectiveness of this bark, the first of the 'plasmodicides', that steps were taken soon to augment the South American source of the drug by cultivating trees in other lands with similar climates. Thus India and the Dutch East Indies became the major producers for what, afterwards, had been analysed and had been found to contain quinine alkaloids.

### Laboratory research

Wars encourage research and improve technology. After the 1914-18 war a great deal of laboratory and clinical

observations were made upon the conditions within which not only the various plasmodia completed their life-cycle, but also the conditions under which the various vectors could live, breed and transmit malaria. With this acquired knowledge there came also the recognition of the various syndromes which characterised malaria and its usual course; also the complications which it might produce.

#### World-wide repercussions from malaria

Thus the story of malaria can be regarded in several distinctive ages. Firstly it was found as an acute fever which caused several million deaths annually throughout the world. This fact was accepted with the hand-bound fatalism of those times.

Then there came the period during which it was supposed that this ravaging pestilence interfered very greatly with the military operations which were the concomitants of expanding and highly competitive trade. Also in this period, perhaps coincidentally with increasing foreign travel, the scourge of ague, which may have been malaria, interfered with the widespread agricultural activities of Great Britain and its nearby continental neighbours.

#### Waning of the disease incidence

Apparently with increasingly good husbandry, which included better land drainage, better crops and healthier and more abundant domestic animals, the disease started to

wane. And about that time the specific 'cure' - cinchona, appeared on the scene and had such an unbelievably beneficial effect that life was transformed, and disabling morbidity made individually, and at length strategically, more tolerable.

The next act opened with the discovery of the cause of the illness and the acquisition of exact knowledge about its essential antecedents. This information narrowed down to definite limits those agues and intermitting fevers which were now to be termed malaria and which would respond to treatment with a plasmodicide.

#### Modern control

Nowadays there is more effective destruction both of the breeding grounds for the mosquitoes and of the infecting organisms themselves. The latter is more efficient, for since it was found that quinine was not after all a wholly successful plasmodicide, several new and efficient drugs have been synthesised and are in common use.

In the last hundred years a great deal of knowledge about malaria has been accumulated. Therefore it should be possible to assess whether or not the ague in Scotland in the eighteenth century was always, or was even frequently, synonymous with malaria. For if it was not malaria, then posterity, when reading authoritative works, should not be led to suppose the opposite.



This assessment has been made on various grounds.

### Vectors and parasites

There are in the United Kingdom only four species of *Anopheles* which are known to be potential carriers of the malady, and which are known to have lived, and still do live, in Scotland.

The species believed to be the vector in Great Britain is *Anopheles maculipennis*. It has two sub-species, *A.m.atroparvus*, which prefers salt water for breeding, and *A.m.messeae*, which prefers freshwater. Furthermore, of these two only the former is believed to be the vector for the only plasmodium, *P.vivax*, which is capable of producing indigenous malaria in the United Kingdom.

However it must be observed that the latter, *A.m.messeae*, is the predominant malarial vector in U.S.S.R. Thus it might be true that two centuries ago it was also a vector for malaria in inland Scotland. Furthermore it is possible that in those times *A.m.atroparvus* bred in freshwater. However, if neither of these possibilities is the truth, then malaria would not have been indigenous in those inland districts where ague was claimed to have been endemic.

Malaria was prevalent in Holland, in the Rhône and Po deltas and in the English coastal districts of Lincolnshire and Essex where the vector was *A.m.atroparvus*.

Therefore the problem is whether this ague in Scotland also could have been vivax malaria. If by environmental factors this could have been so, then, though it is unlikely, it is just possible that *A.m.messeae* could have become anthropophilic; and *A.m.atroparvus* just possibly could have bred inland and thus have simulated the distribution of ague as recorded in the Statistical Account.

In the interests of complete accuracy it must be recorded that there are still some laboratory-bred mosquitoes as well as 'wild' ones. There are still some laboratory specimens of plasmodia. Furthermore persons do arrive in this country carrying *P.falciparum* and may perchance have these parasites taken by a vector and passed on to another victim. Even so environmental factors are seldom suitable for the plasmodial cycle to complete its round, and it is thought to be very doubtful, if not impossible, that *P.falciparum*, *P.ovale* and *P.malariae* would be spread in the environmental circumstances of Great Britain.

#### Environmental factors

These environmental factors are, as far as the plasmodia are concerned, the maintenance of a temperature of at least 60°F for a critical, though uncertain period of hours, after the mosquito's blood meal. Thereafter, within broader, but still narrow limits the intra-anopheline life-cycle of the plasmodium is completed, but not if the temperature falls below 60°F. As far as

*P. vivax* is concerned, at this figure the cycle takes 53 days to complete, according to one authority, and all authorities agree that it is not less than 30 days.

### Meteorological factors

It can be shown that even in summer the temperature in Scotland is not maintained at or above the critical figure of 60°F except on very few days in any decade.

Evidence will also be given which suggests that at least in the matter of mean summer temperatures the variation in Scotland over the last two centuries has been of the order of one half a degree Fahrenheit warmer now than then. So that changes in the external temperatures cannot account for the dying out of ague. It is equally certain that the prevailing external temperatures are quite unsuitable for the maintenance and spread of malaria.

### House warming by in-dwelling animals

It has been said already that the vector mosquitoes are preferentially zoophilic. Indeed when someone in 1920 wanted to find a continuing supply of mosquitoes it was realised that the only way of doing so was to collect the insects from occupied pig-sties.

It is highly probable that keeping such animals as cows or horses or pigs in small sties or stables raises the temperature in that building to such a degree as to

encourage anopheline mosquitoes to live and hibernate there. Presently it is considered that pigs and not cattle are the prime choice of *A.m.atroparvus* for its food source. It is at least a possibility that this is now the case because pig-sties are still small, ill-lit 'rooms' as compared with the modern cow-houses, which are tall and airy and light. Furthermore as it is critical for the intra-anopheline plasmodial cycle that the ambient temperature should be suitable, it can readily be understood that that factor is more readily attained by the added warmth given out by animals resident in a smaller sty rather than a larger byre.

#### Survival of vectors and parasites

However, just because a mosquito roosts in a pigsty, it does not necessarily mean that the species will be adequately propagated. The male mosquitoes die off in the winter. The species does not die out, however, for the autumn and summer laid ova can survive at most stages of their development even though the temperatures are below the winter mean. Although the female mosquitoes may survive, it is also true that the parasites already in the mosquitoes only survive to a minimal degree, and only in that species of mosquito, *A.m.atroparvus*, which lives indoors. It is now believed that *A.m.messeae*, the fresh-water egg-layer, is a true hibernator, living on its own fat and not feeding throughout the period of hibernation. Furthermore it does not harbour viable plasmodia throughout this time. It is straining credibility too far to



suppose that the temperature in a sty could be raised for the winter six months to 60°F by the presence of any animals. The mean temperatures from October to March at Dundee are 40.1°F and from November to March, 38.8°F. For this reason alone *P.vivax* parasites could not survive the winter in either *A.m.atroparvus* or *A.m.messeae*. The latter hibernate, and if the former had become infected during the late autumn, it is inconceivable that the parasite cycle would have found temperatures sufficient for its development. Thus any parasite must have survived the winter only in a human carrier. For it is only a remote possibility that some mature parasites survive the winter in the appropriate vector. Only a very small percentage do so in the Netherlands.

#### Improved housing and farming conditions

In the mid-eighteenth century, with improving husbandry and the enclosure of fields, housing and feeding conditions for both man and beast improved. Thus the animals could be retained throughout the year by virtue of the relative abundance of winter feed. With winter feeding it became possible to keep cattle in the towns as well as in the immediate environs, for the production of milk as well as beef. The town-housed cattle were still folded into stables in juxta-position to human dwelling houses after ague died out. So this reinforces the theory that even under favourable circumstances the winter and spring external temperatures were too low, possibly, for mosquito breeding and certainly for plasmodial development.

It is not until the end of May, that local mosquitoes hatch out in any numbers and there are many years when the temperatures even then are unsuitable for the hatching out of mosquitoes and the development of plasmodia. So, any cases of malaria occurring before then in any year are either relapses or those that do not develop clinically for about 26 weeks after inoculation - i.e. the spring intermittents.

#### Ratio of vectors to animal food supply

When the matter of the dying out of proven malaria has been written about in respect of other areas, often the conclusive factor is believed to have been the ratio of vectors to cattle. When the numbers of the latter fall below some critical proportion, malaria returns to attack the human population, although only if all the conditions are correct.

It was written for the Statistical Account that in 1792 Longforgan had 900 cattle and that there were 40 farmers. Although this is a lot of cattle, previously, at least in summer, there had been more. However, the disease died out instead of increasing through comparative lack of animal hosts. There may have been more pigs and horses and certainly there were more sheep in some parishes. Horses were not kept in large numbers, though the parish of Logie had 140. Sheep are comparatively unattractive to mosquitoes, and pigs were believed not to have been very plentiful in what are reported as having been the ague areas. So it seems that this theory on the

transference and endemicity of malaria might also be invalid in this particular case. However though one may pay particular attention to the changing cattle accommodation, one must also make particular exception for the pigs and goats, the former of which at least were accommodated for all their wants around the human houses. The latter, however, are of no concern in this context as they, too, are a low priority in the scale of mosquito food supplies. Nevertheless they existed then in such numbers as to have been a possible factor in the incidence of 'ague', though perhaps for a totally different reason, for ague might have been brucellosis.

#### Conditions in various dwellings

There are few published figures which show the extent to which the temperature for house or sty-dwelling mosquitoes is raised by the presence of cows or pigs. So the value of the factor of temperature as a limitation must be largely surmised. Some may think that the evidence is marginally in favour of the idea that *A. m. atroparvus* lives in conditions in which the temperature will be suitable for plasmodial development for a very short period each year. Indeed this must have been the case in the malarial districts in England.

Modern dairy research programmes have investigated the fringe of this problem. They have been concerned to find out the optimum temperature for the feeding/growth ratio for neo-natal calves and pigs. These are not the



same. In the interpretation of their findings one must recollect that modern animal breeding sites house their animals in quarters which differ greatly from those of 200 years ago. In the eighteenth century often there was insufficient straw to feed the animals, let alone to put into their stalls to keep them warm. Nor were the 'houses' made of modern materials; nor may one suppose that walls and doors were draught-proof.

Many of the cattle that remained on the farm throughout the year lived away from the human dwellings, in the field enclosures. The farm labourers' beasts may have lived in their masters' smoke-filled houses. No mosquito would dwell in such an atmosphere. Latterly, on the better farms, there were semi-detached animal dwellings in which no doubt the mosquitoes would roost.

The modern work done on the degree by which a small 'barnful' of animals could raise the ambient temperature, propounds that this is of the order of two, or at the most four degrees Fahrenheit, depending upon the degree of the external temperature.

Suppose this situation to have existed. The mosquitoes which fed on plasmodial infected human blood after dark spent those next important hours in the animal houses. There, just conceivably, though improbably, the temperature in summer could be augmented by the animals' presence to the critical  $60^{\circ}\text{F}$  at which the cycle takes six

or seven weeks to complete. In that case the question is raised immediately why, if there are such animals in the house in which the mosquitoes harbour, should these preferentially zoophilic insects turn anthropophilic.

It has been suggested that one of the main reasons for the dying out of malaria is that of the mosquito-animal-men ratios being augmented in favour of the preferred animal food source; or, conversely, diminished with consequential adoption of a human food source. Such situations have occurred within the last 40 years in neighbouring countries. However, in the days when the cattle were retained around the farm-steading, and had thus provided the essential temperature factor, they would have formed the prime target for the insects' food sources. If the cattle had been sold to the English market then, although the mosquitoes might have of necessity turned anthropophilic, yet the cattle would not have been present to raise the temperatures sufficiently for the plasmodial development.

### Pig-keeping

Ure recorded that in Roxburghshire in 1794 the rearing of swine was 50 times greater than it was 40 years previously; that is to say in the middle of the century. On the other hand many writers state that there was a prejudice against pig-keeping and Burt 'never saw a swine in the Highlands'.

Nevertheless one modern writer states categorically

that anophelenes prefer feeding on pigs to cattle. Furthermore pigs can be fed on less elegant food than cows, and thus may be retained when cows must be sold. Also, pigs can be, were and are housed in smaller, more easily warmed shelters than cows. And pigs might have been allowed to share the living rooms of the farm labourers. Therefore all this might add up to a major factor in the dying out of 'malaria' at the end of the century. However the question of temperatures is the paramount stumbling block.

The numbers of pigs slaughtered in Edinburgh in 1775 was not recorded. This would have given an indication of their numbers. It is unfortunate that bacon or pork are not mentioned as being food for any other than the well-to-do, and not often for them. So there is no method of assessing the possibility that pigs were available in numbers sufficient to satisfy the temperature requirements of the plasmodial anophelene cycle. Indeed even if the increased keeping of pigs was an important factor, this goes nowhere to explain how the mosquitoes found suitably warmed resting places before this profusion of pig-sties started. Indeed it does not explain why 'malaria' did not return when conditions returned towards the situation that exists nowadays when there are too few pigs to act as diversions from humans as food supplies.

#### Land drainage at home and abroad

The disappearance of ague has been correlated with the drainage of lands, suggesting that there came a time



when there were no longer sufficient breeding grounds for the supply of mosquitoes necessary to promote the annual scourge of 'malaria'.

It is the present belief that there are still ample breeding places not only in Scotland but also in the more recently malarious areas like the Netherlands, and indeed the Lincolnshire Fens. Many of the continental breeding areas have been drained. Many more remain to be drained. Nevertheless 'malaria' has died out in all these places.

#### Necessity of having plasmodial carriers and vectors

It was only when the prime animal food supplies diminished in times of war, as in the Netherlands and in the Rhone delta, that malaria returned as a human infection; and then on one condition. This was, and remains, the presence of a human carrier of plasmodia. This condition was also satisfied in 1925 when the Malaria Reference Laboratory was established near Epsom. The mosquitoes and the human carriers of plasmodia were all there. In addition, nowadays, to reinforce the drainage of lands, the modern insecticides help to reduce the numbers of anophelene mosquitoes. Until effective anti-larval sprays became available during the 1939-45 war, the mosquitoes could breed freely and successfully in many localities.

In eighteenth century Scotland we may surmise that the vectors were present as they are now. The numbers may have been diminished by land drainage, but were not reduced by insecticides. Without laboratory evidence it

is impossible to know whether or not plasmodia were present.

Thus, although it seems that the conditions were inadequate for plasmodial development, some may have been transferred to Scotland by carriers. This is made more probable in respect of the fact that in the eighteenth century effective plasmodicides were probably not available for the labouring classes who were those alleged to suffer so greatly from malaria.

#### Hazards of modern transport

It is a very different story in these modern days of quick transit from malarious areas to the United Kingdom. By the very ease with which a person can be transported, so also can the developing, or in some other way undisclosed, disease be translated. Thus possibly malaria could become prevalent again in Great Britain as it has been believed to have been prevalent in an earlier age. However modern plasmodicides destroy plasmodia which the previously used quinine did not, however pure it was. So anyone visiting an endemic area is wise to take such precautions as are readily available and unprovokingly effective.

However although this problem of the provision of carriers was a significant one it was probably no greater than, nor as great as that of the provision of temperatures suitable for plasmodial development. Nevertheless the provision of carriers will be investigated.

### Possible carriers

The obvious sources of the army, navy, merchant navy and civilian travellers will be discussed. It seems that even when the army returned from malarious areas, ague was not renewed in those parishes to which the soldiers might have returned. The same comment applies to the navy, but with the addition that sailors served in areas where the malaria was usually more prominently falciparum malaria rather than the less fatal vivax malaria. Apart altogether from this greater mortality rate it is believed that conditions in Great Britain are unsuitable for falciparum malaria to become indigenous. Civilian travellers to foreign shores did not report themselves ill with anything resembling malaria. Furthermore those travellers were probably not of the labouring class. Those used to go to the Fen district which was malarious, and which may have been regularly reinfected by immigrants from Holland where malaria existed until the present century. Indeed the Netherlands were not declared a malaria free area by the World Health Organisation until 1970. There were also the visiting Dutch sailors and merchants. They called at many places in Scotland where neither ague nor intermittent fever were said to exist. Indeed the opposite is also true that ague was said to exist in many places which - probably - Dutch sailors did not visit; places like Ednam and Morebattle. There were also other ports of call such as Lerwick and Tongue where it is almost inconceivable that conditions for the spread and maintenance of malaria were ever suitable.



Thus it seems that the evidence for the widespread transference of malaria to places in Scotland is at least doubtful. This is made a more potent doubt by the notion that it died out there before the end of the eighteenth century, long before it was eradicated from nearby England, and not far distant Holland. It has been said that the civilian travellers included temporarily emigrant farm labourers to East Anglia. There is only one record of such a person returning with what might have been malaria. Moreover the cattle drovers went annually to those parts during the malarial season. Although they did not live under the same roof as the cattle which comprised the drove, it is strange that apparently they did not return to their native parishes and there transmit any ague-like disease to their neighbours - but carried on their arduous duties with no recorded illnesses.

#### 'Malaria' in inland villages

In 1782 the farming in the Merse flourished. It was therefore extremely improbable that many labourers went south looking for alternative jobs during the harvest season, and so it is altogether surprising to find that more than a 100 of those admitted to the Kelso hospital with 'malaria' the next spring had contracted it in 'foreign' parts, and had brought it home. And this must have been the sequence, for villages like Nenthorn and Earlston and Morebattle are far from the littoral breeding grounds of *A.m.atroparvus*. Thus all the patients cannot have been infected locally, at least by that species of mosquito.

### Lack of children carriers

Nowadays it does not take long to relieve an attack of malaria. Before the days of readily available 'quinine', in a highly 'malarious' area such as the Carse of Gowrie or the Merse, almost certainly there must have been some chronic malarial carriers. Usually these are children. They are often readily recognisable by the enlargement of the spleen. Although this feature apparently occurs less frequently the further north the disease occurs, yet only one possible record of this has been found. Although the infant mortality rate was high, in many areas it went unrecorded. However the Kelso Dispensary records do not support the idea of continuing involvement of childhood carriers, even though they record many admissions of those with ague. Perhaps the children died meanwhile of some other illness.

### Spring intermittents

It appears to be certain that in those areas which were malarious such as East Anglia and the Netherlands, the spring intermittents were a regular feature. It was believed that the phenomenon was associated with small doses of plasmodia injected the previous autumn towards the end of the season suitable for the intra-anopheline development of *P. vivax*. Indeed it has been observed that plasmodia can scarcely survive the winter in such localities. Thus if malaria is endemic the plasmodia must survive in the human hosts.

However although the records claim that the annual incidence of ague in Scotland interfered regularly with spring sowing of crops, if such illnesses were malaria it would be reasonable to suppose that there would be a high incidence in the autumn previous to a year which provided many incidents of the spring intermittents. This supposition is not borne out by the available hospital records. For in order that there shall have been a sufficiency of injected plasmodia in, say October it must be the case that the August or September temperatures were, or with animal presence could have become, suitable for plasmodial development. And this developmental suitability would have applied to late summer acute cases of ague as well as spring intermittents. In most years this was evidently not the case.

### Conclusion

Ague was an acute fever which was said to have occurred in epidemics in spring and autumn. One cannot know whether or not it was malaria because such a diagnosis could not be proved. However if it was so, it must have been vivax malaria.

All these matters will be examined hereafter and will point to the conclusion that ague was not invariably malaria and certainly not in the form of an annual scourge. Nevertheless some questions will remain to be answered. In particular it would be interesting to find out what was the decisive factor which permitted 'malaria' to disappear



from Scotland 80 years before it did so in England.

Evidently it was not the effective drainage. Evidently it was not solely the increase in animal numbers for that factor also did not prevent malaria existing in East Anglia for a further hundred years. Nor would it have been the greater availability of quinine in Scotland relative to England. Perhaps it was the unsuitability of the Scottish temperatures.

And if ague was not malaria, the other question of its exact nature also requires to be solved. Some alternative diagnoses will be suggested in the final chapter.

## CHAPTER 2

Etymology and definition of terms.      Geographical  
distribution of ague in Scotland.

### Mala-aria

The word malaria was introduced into the English language by Horace Walpole about 1740. He had been staying near Rome and had written to a friend about the 'mala-aria' which was the cause of so much illness thereabouts. (1) The word is derived from the two Italian words 'mala' 'aria' which mean 'bad air'. Although this was before the period in which the cause of malaria and its method of transmission became known, it was recognised that the disease of the Roman Campagna was similar to the agues of the English marshlands. These were indeed believed to be caused by the marsh miasmata. Thus the word 'malaria' was first used in English to denote marsh effluvia and bad smells. The 'malaria of much filth' in Edinburgh had been reported, and Arnot wrote of an Edinburgh tenement, 'If any malaria or contagion exist in the house, the probability of it passing from dwelling to dwelling on the same stair is much greater than if there was no communication but the open air'. (2)

### Agues and intermittent fevers

Until the mid-nineteenth century the terms 'agues' and 'intermitting fevers' had been in general use. They were referred to not only in medical textbooks but also in general works such as the Statistical Account of Scotland.

Buchan, writing in 1774 about these illnesses, said they should mean 'fevers which during the time the patient is ill have evident remission of the symptoms'. (3)

Cullen described them as 'fevers which arise from marsh miasmata consisting of many paroxysms with intermission or at least evident remission intervening, returning with remarkable exacerbation and in general with shivering; one paroxysm only per day'. (4)

It was noted that they had a variety of symptoms but were not accompanied with cutaneous eruptions such as smallpox and erysipelas were. Furthermore it was observed that they were most frequently found where the soil was marshy as in Holland; the Fens of Cambridgeshire and the Hundreds of Essex. (3) The textbook authors never refer to ague in Scotland nor Ireland.

A modern dictionary defines ague as 'an acute fever, especially a malarial fever marked by successive fits and paroxysms consisting of a cold, hot and sweating stage'. (5) Johnson, writing in 1755, agreed with this but did not include the word 'malaria' which had not been adopted into the English language by that date. (6)



The word 'ague' is derived from the Latin 'acutus' meaning sudden or sharpened. It was thus applied to many acute fevers and many writers draw attention to diverse details. Several modern writers have stated that the terms 'ague' and 'malaria' are synonymous. This cannot be the case although malaria is an ague. (7) (8)

### Malaria

Malaria is now defined as 'A protozoal disease caused by various species of plasmodium which infect the red corpuscles and give rise to periodic fever, splenomegaly and anaemia; transmission is by anopheline mosquitoes'. (9)

Although Hippocrates and Columella suspected that mosquitoes might be involved in the causation of ague, it was not possible to be certain of this until the end of the nineteenth century when not only the infecting organisms had been isolated but also the vectors, anopheline mosquitoes, had been found to transmit these organisms to man. Since that time malaria may be diagnosed only on finding the parasites in the blood of the patient. Thus it is impossible to be certain that all the agues and intermitting fevers described in the past were malarial. The terms are not interchangeable.

### Clinical notes on ague

It has already been observed that there are many types of ague. Indeed a book was written by Talbor

entitled 'Pyretologia: A Rational Account of the Cause and Cure of Agues'. (10) Clinical descriptions of some cases of ague cannot possibly be confused with malaria.

Monro wrote in 1781 of 'A young man who complained of pain when he passed water. He was seized with paroxysms which had the full type of ague but without regular returns. The aguish paroxysms went off gradually.' (11) And on another occasion he wrote of 'A 37 year old woman who had almost daily paroxysms of ague from November 1728 until 8th October 1730. At last an abscess developed in her right arm which when evacuated she had no further paroxysms.' (12) There is an entry into the admission records of Kelso Dispensary, 'On March 2nd 1787 Jean Rutherford was admitted with ague-smallpox'. (13)

#### Sources of information

It seems probable that when Sydenham, Buchan and Cullen referred to agues and intermitting fevers they referred largely to conditions occurring in England where they practised medicine. However there are records of hospital admissions for these illnesses in both Edinburgh and Kelso. There are also some manuscript notes by physicians practising in the Lowlands of Scotland. (14) (15) (16) In the travellers diaries kept by those who travelled not only through Scotland but also to foreign lands there are scarcely any references to this disease. (17) (18) (19) (20) (21) (22) (23) (24) (25)

The chief source of information about Scotland is the Statistical Account. (26) This was commissioned by

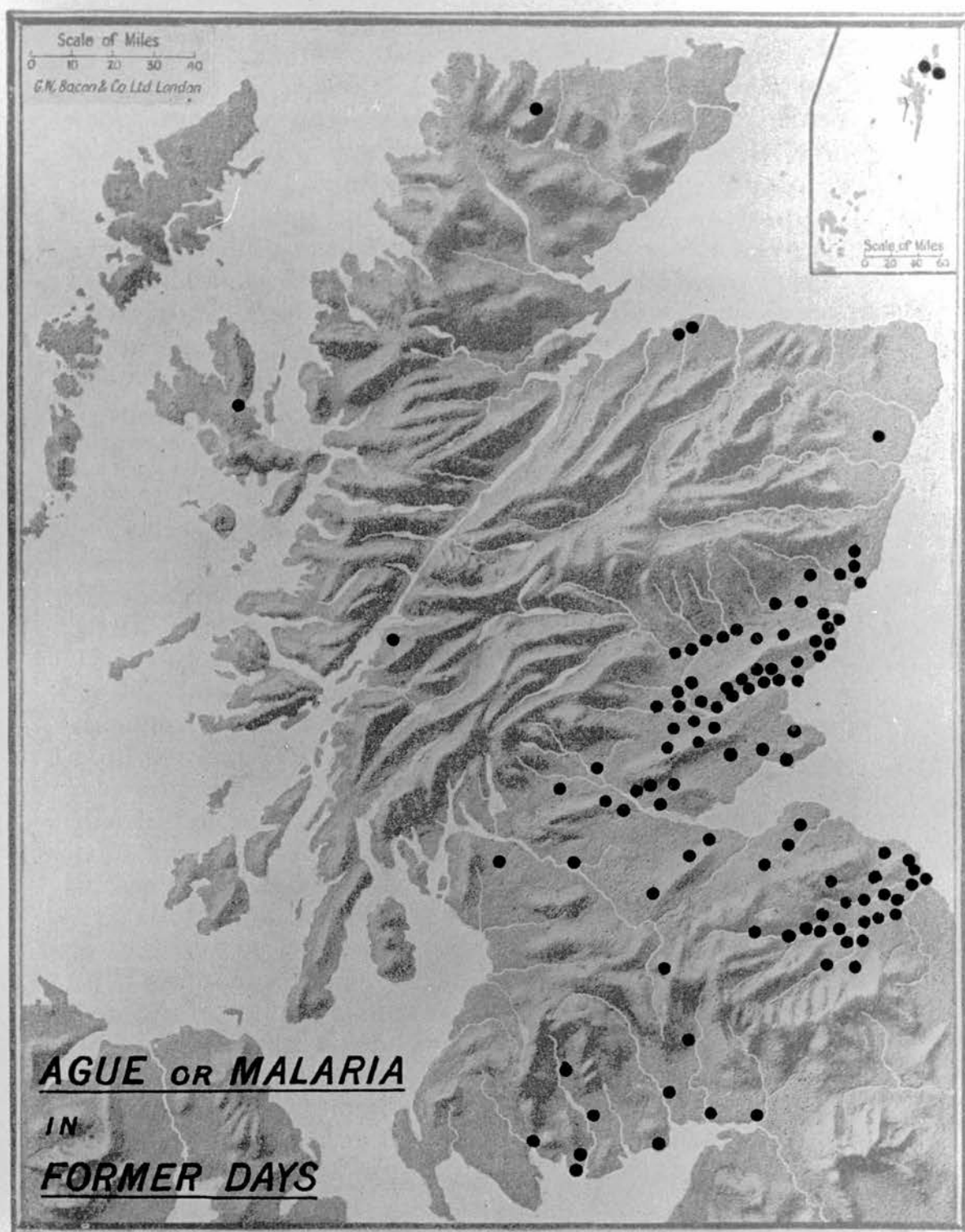


Sinclair in 1790. Information was produced from every parish in the country. Each account noted the parish boundaries and its topographical details. It remarked on the local industries and housing, the population, vital statistics and illnesses and many other matters of abiding interest. From this source Ritchie compiled the map (Figure 1) which shows the location of those parishes in which ague was reported. (7)

### Geographical distribution of ague in Scotland

It is apparent that the parishes occur largely in the Forth and Tay estuaries and the Tweed valley, but they are not confined to those parishes adjoining the sea. There are several localities far inland. There are none in the Clyde estuary nor on that coast where the Gulf Stream influences the temperature. Nor are there any in the Highlands except for five places. These are the parishes of Appin, Portree, Tongue and two parishes in the Shetland Islands. As a matter of fact ague was also reported from the island of 'Tire-iy' but not in the Statistical Account. (21) Of the Shetlands Martin wrote that there was an annual invasion of 'Hollanders who come in their fishing busses in great numbers upon the coast for herrings. The proprietors are considerable gainers by letting their houses from June to August.' (27) Malaria was indigenous in Holland. Modern authorities claim that new cases do not arise there before August. Nevertheless some members of the crews of two thousand busses might have had malaria and might not have been cured by the





**DISTRIBUTION OF AGUE OR MALARIA IN SCOTLAND IN  
THE 18th CENTURY.**

Each dot indicates a parish where Ague was common.

**FIGURE I**

This is taken from Ritchie, J. (1920): *Influence of Man on Animal Life in Scotland.* p.508 Cambridge. (By permission of the publishers Cambridge University Press and by the author's literary executor, Professor A.E. Ritchie, F.R.S.)

treatments available in that era for they might also have had small autumnal doses of parasites and not have had clinical attacks until the following spring. Thus it is just possible that they might have carried the infection to those two parishes in Shetland, and Tongue. Two hundred years later the same hazard was envisaged in a government instruction issued in 1920 to all practising doctors on the possible incidence of malaria in Scotland. The doctors were warned that malaria might become endemic as a result of the homecoming of carriers who had been infected with malaria during the 1914-18 war. However it also seemed to show that the *Anopheles maculipennis* group were not found so far north as Shetland, nor indeed as far north as Tongue. (28) Thus in modern times malaria would not become indigenous in those parts.

#### Local prevalence of ague

The Statistical Account records that in many parishes the prevalence of ague was so great that, as in Abernyte, 'If a farmer wanted four of his cottagers for any piece of work he generally ordered six, knowing the probability that some of them, before the work could be finished, would be rendered unfit for labour by an attack of the ague'. (29) In several parishes such as St Vigeans, 'The incumbent had often seen in the months of March, April and May and sometimes in autumn from 15-25 persons in that distemper (ague). These were present for many years after 1754 but not for the last twenty years.' (30)

It is noteworthy that many of the parishes which recorded the prevalence of ague are situated on high ground, or on ground many miles from the sea-coast. It will be shown later that the vector mosquito prefers to breed in slightly salty water. The following parishes are not near salt water but were notorious for the presence of ague. They are Abernyte and Kilspindie, Kirkden and Careston in Angus; Earlston, Innerleithen and Kelso in the Border country.

Similarly it is recorded that in parishes such as Dirleton, 'Agues are common', yet in contiguous parishes such as Gladsmuir, 'It was rare'. (31) (32) Even the parish of Lundie and Fowlis next to the notorious Abernyte had no local distempers.

#### Land drainage

Throughout the account special mention was made about the dying out of ague coincidentally with the drainage of lands. However there are apparent inconsistencies. There is no mention of agues in Edinburgh in the Statistical Account, although in the New Statistical Account written in 1845 it was said that 'agues and inter-mitting fevers were common a century ago'. (33) The latter report goes on to record the nuisance of the irrigated meadows in and around the city.

In the first Statistical Account it was noted of Cramond that 'Agues some years ago afflicted the common



people so much that the necessary work was with difficulty performed for want of hands. Since 1775 it has almost totally disappeared by the thorough drainage of the lands.' (34) However in the adjoining parish of Dalmeny there is no mention of the disease and in Corstorphine (Although the village hath generally been reported to be in an unhealthy situation by reason of dampness ... I have never seen the intermittent fever in any form'. (35) (36)

#### Accuracy of records

There can be no doubt that in many parishes throughout the country an acute fever was common. However as happened in later years in England such a fever might have been regarded as being so common that it was not worthy of a special recording. Thus ague may have been common in many parishes in which it was not specifically mentioned. This is unlikely as a generality for most of the accounts specifically did mention illnesses and many were precise enough to remark on such complaints as scurvy and smallpox, measles and consumptions (sic).

#### Interpretation of events

The facts were there. The interpretation of them might have been faulty. The writers of the accounts were usually the parish ministers who would not have had any precise medical knowledge and for whom there were no aids to diagnosis, not even a thermometer. Thus the occurrence of cold fits and hot fits must have been matters for observation, and their recording was probably

often only by word of mouth and not by writing. Thus one can readily imagine how an episode of ague in the occupant of a cottage came to the notice of the parish recorder. Inasmuch as the recorders were the parish ministers, it may be assumed that they certainly knew the conditions in which their parishioners lived. Thus it is important to note that agues and intermitting fevers were declared to be diseases of the farm labourers and specifically not of the well-to-do persons. (37) The latter might have been expected to travel to those adjacent lands in which malaria was later proved to be present, and thus where the indigenous agues of the eighteenth century were probably malarial.

#### The Kirkbean Record

The farm labourers and cattle drovers may have emigrated temporarily to find work in East Anglia. Indeed the Statistical Account for Kirkbean specifically mentions this. (38) 'Formerly many of the inhabitants went into Lincolnshire for employment during the harvest and returned infected with ague; now they have work sufficient to employ them in the parish and the disease is seldom a complaint. Inoculation is frequent and successful.'

Thus there are two further points to be made. Firstly agues died out contemporaneously with the cessation of the practice of going to the malarious Fenland for temporary and seasonal farm work. Secondly, inasmuch as the next sentence refers to inoculation being successful, this must



cast some doubt on the former illness being malaria. It may of course be the case that the author was merely remarking on the successful introduction of vaccination against smallpox which was prevalent in those times. Exactly the same record was made at Melrose. (39) However there is no mention of smallpox in either account.

### Farming records

It is strange that detailed accounts of farming practices in Scotland make no mention of the farm labourers contracting ague even though this is at variance with the Statistical Account records. (40) (41) (42) Such a record has been found in England in the county of Oxfordshire where no salt water breeding anophelene vector could be found. (43) Besides this, various agricultural reviews, all written about 1790, do remark on the temporary labour given by Highlanders for farm work and drainage schemes in areas which had been declared aguish. There is no account of such labourers returning to their villages and becoming sources of infection for their local communities.

Certainly the accounts for Leuchars and Mid-Calder might be interpreted correctly as referring to malaria. 'I know a person who when he lived in a dry country and on the sea-coast had frequent severe fits of the ague: but, upon coming into the neighbourhood of the marshy part of this parish and into a moorish situation he was



soon relieved and for a considerable time past he has had no returns of his disease.' (45) At least he had succumbed to his illness whilst living near the sea coast. At least the inland marshes and their miasmata did not reinfect him. For as will be shown the only probable malarial vector was found on the coasts and not inland.

### Conclusions

It is quite certain that there were several different forms of ague. The term seems to have been used for many acute fevers which were not distinguishable by reason of a rash or some other striking feature. Thus it cannot be correct to make it synonymous with the term malaria.

The location of parishes where ague was mentioned by the writers of the Statistical Account has been mapped. It shows that generally the affected parishes lie in Berwickshire and along the estuaries of the Forth and Tay. Anomalies are noted. They include some 'aguish' parishes far distant from salt water, and others in which no agues are recorded although they adjoined areas of great endemicity. Attention is drawn to the possibility of wrong interpretations of illnesses by the authors of the accounts who probably did not have any precise medical knowledge. Also attention has been drawn to the possibility, as in England, that agues were so common as to be considered not worthy of record.

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### CHAPTER 3

Malaria - the parasites.

Only four of the large number of species of plasmodia can cause malaria in human beings. A fifth, *Plasmodium knowlesii*, causes malaria in monkeys but has been known to infect man. (1) However, it has never been known to cause human malaria in Great Britain under natural circumstances.

#### *Plasmodium Ovale*

Stephens first recognised this parasite in 1922. It is rare and had only been isolated on 105 occasions between 1922 and 1949. (2) A high degree of immunity is conferred by one attack. Thus it cannot have been the main infecting agent in Scotland. Another characteristic, which is that its intra-anopheline cycle takes 15 days at 77°F and correspondingly longer at lower temperatures, rules out the possibility that it can have caused endemic malaria in Great Britain.

#### *Plasmodium falciparum* and malignant malaria

Shute's laboratory investigations into the transmission of malaria showed that *Anopheles maculipennis atroparvus* was the mosquito which transmitted the greatest number of plasmodial strains. (3) Nevertheless

it appeared to be impossible that *P.falciparum* could undergo development in this insect. It was then found that there were different strains of the parasite, the tropical ones of which are not transmissible by *A.m.atroparvus*. This mosquito will however transmit strains indigenous to some countries of eastern Europe and Italy. (4)

When it has done so successfully a human being develops malignant malaria. This disease has a high mortality rate and would have had an even higher one in that age when the only possible plasmodicide was quinine. Buchan wrote in 1774, 'The only patient whom I remember to have lost in an intermitting fever evidently killed himself by drinking strong liquor which some person had persuaded him would prove an infallible remedy'. (5) Furthermore, *P.falciparum* takes 10-12 days at 77°F to complete its intra-anopheline cycle, and 23 days at 68°F. (6)

It is therefore impossible to believe that this parasite was the cause of the indigenous 'malaria' of Scotland.

#### Plasmodium malariae and quartan malaria

Not only does this parasite take 15-21 days to complete its intra-anopheline cycle at 77°F, and much longer at lower temperatures, but Shute found that it was almost impossible to infect *A.m. atroparvus* with this parasite. (7) Indeed James in London succeeded in only 10 out of 305 attempts, and de Buck in Vienna in 30 out



of 263 attempts to do so. (8) Furthermore both these observations were made under laboratory conditions. *Anopheles stephensi* will carry out the function of transmission but this mosquito has never been found in Great Britain. Thus, if it is correct that *A.m.atroparvus* was the only malarial vector to be found in Great Britain, then *P. malariae* cannot have been the infecting agent in this country.

Many eighteenth century writers referred to the quartan pattern of the fevers about which they wrote. In this type of malaria Kitchen noted that at the start of the disease the quartan pattern was not immediately adopted, and the paroxysms might at that point be quotidian. (9) This is due to the differing times at which the injected parasites reach maturity and burst out of the red cells. As the days pass the immune response becomes greater. Thus more parasites are disposed of and the remainder form one batch which alone sporulates, producing the typical temperature chart appearance.

#### Plasmodium vivax and benign tertian malaria

It is therefore the case that only *P.vivax*, the organism associated with benign tertian malaria, could have been responsible for indigenous malaria in Great Britain. This disease had in general a low mortality rate, except in those who were debilitated from some other cause. This coincides with the views expressed by Buchan, Sydenham and Monro.

Although the descriptions of the disease by such writers constantly drew attention to the temperature patterns, these may have been confused one with another at the start of any attack of malarial fever. Indeed the recorded patterns could not have been indisputably accurate because of the lack of thermometers. Thus the fever pattern of malaria was probably solely related to the occurrence of the rigors. These coincide with the release of pyrogenic material into the blood-stream. Some of these fever-producing merozoites reinfect circulating red cells. Some are disposed of by the body's anti-invasive forces. Some become sexually differentiated.

#### Intra-anopheline cycle

If an efficient vector mosquito feeds on the human carrier at this point it may ingest some of these gametocytes and, as food for itself, some red blood corpuscles. A zygote is formed and penetrates the wall of the insect's stomach where it becomes encapsulated to form an oocyst. The nucleus then divides forming large numbers of sporozoites which eventually migrate towards and into the salivary glands. There they remain and thence may be injected into another human being.

#### Temperature requirements

Many observations have been made on the intra-anopheline cycle of the plasmodium under laboratory conditions. These probably differ from naturally-occurring



circumstances in the matter of controlled temperatures and humidity. These need not vary in a laboratory. They do vary every day in natural circumstances. Under laboratory conditions the intra-anopheline cycle takes 8-12 days at  $75^{\circ}\text{F}$ . However if the surrounding temperature is only  $61^{\circ}\text{F}$  the development takes 30 days. Wenyon asserted that in the Balkans the cycle took 40 days at  $62^{\circ}\text{F}$ .<sup>(10)</sup> Jancso claimed that the lowest temperature at which the vivax parasite would develop in the mosquito was  $59^{\circ}\text{F}$  and this temperature took the cycle 53 days. (10) All authorities agree that the cycle will not be fulfilled below  $59^{\circ}\text{F}$ , and the more generally agreed figure is  $60^{\circ}\text{F}$ . (11) This means that the range of endemic malaria is governed by the 60 isotherm, that is to say all those places having a temperature of  $60^{\circ}\text{F}$  or more for 85 days in the year. This does not include Scotland.

Numerous authorities have stated that the temperature must not fall below a certain point after ingestion of the parasite into the vector. Grassi regarded such a temperature as critical for the process of exflagellation. James claimed that this process took place within 15 minutes at a temperature of  $77^{\circ}\text{F}$ . At  $64^{\circ}\text{F}$  -  $66^{\circ}\text{F}$  there was no such change within an hour. Jancso, however, considered that the critical temperature was necessary for the ookinete to penetrate the stomach wall preliminary to oocyte formation. (12) Whichever may be the case evidently it is necessary that the temperature does not fall below  $60^{\circ}\text{F}$  during this critical period



which is probably within two hours after the mosquito has fed on the plasmodia-infected blood. Indeed Grassi claims that the minimal temperature for *P.vivax* is 63°F. (10) (11) Such a temperature persisted overnight in Scotland on only three occasions in the exceptionally hot summer of 1975.

However such a temperature need not persist for the whole cycle for oocyte formation can proceed at temperatures as low as 49°F, but in this case the development takes 30 days. James found that they could survive for six days at temperatures consistently below freezing point if the temperature is corrected thereafter. (11) And Brumpt found that the blood of a patient remained virulent for about 24 hours at a temperature of 60°F - 68°F, and for 75 hours having been kept in contact with melting ice. (13) However the latter observations do not occur in natural surroundings, and blood transfusion was not undertaken in eighteenth century Scotland. However Macdonald considered that in England the maintenance of a mean temperature of 60°F for 16 days was necessary to initiate transmission of *P.vivax*. (14)

#### Asexual cycle

If a mosquito has plasmodia in its salivary glands, these will be transmitted to the new host in the act of feeding. The parasites circulate in the peripheral blood for about half an hour and then migrate to the liver parenchyma cells. Nuclear division starts and

schizonts are formed. When these are mature they may have 2,000 or more nuclei. Each one of these becomes covered by a thin film of cytoplasm, and about the eighth to twelfth day after infection the liver cell ruptures setting free the merozoites into the peripheral circulation. (15) Each one, on reaching the blood-stream, enters an erythrocyte. The so-called trophozoite parasitises the haemoglobin and after two or three days during which nuclear division again takes place, the erythrocyte ruptures releasing the pyrogenic merozoites into the blood-stream. At this point the host's temperature rises and he has a rigor. The maximum number of parasites are found in the peripheral blood about 12 days after the initial rigor in a first attack, but after only two or three in the person who has had a relapse.

#### Pattern of clinical attack

At the start of a first attack of vivax malaria when there is no immunity the tertian pattern of rigors and rising temperatures will probably not appear immediately. A quotidian pattern of such events may prevail. Only when the sporulation pattern is well defined will the typical alternate day series of events take place. Then parasites which might have disrupted this pattern will have been disposed of by the developing immunological processes.

#### Indigenous malaria

It is tautologically correct to state that if someone who has been infected with malaria whilst abroad develops

the disease on return to Great Britain and thereafter has some of his parasites transmitted to another human being by a vector mosquito, under these circumstances the malaria is indigenous. However it is usually taken to imply that a series of occurrences of malaria due to the same type of parasite occur in the same locality over the period of a year or more. This circumstance is more likely to occur when there are no effective plasmodicides available. Often this may have been the case in the eighteenth century in Scotland. Broughton-Alcock in 1921 found *P.vivax* in the blood of 2.7% of 620 persons who were drawing pensions in the United Kingdom for malaria contracted in the Orient during the 1914-1918 war although none of them had left the country during the preceding three years. (16) Thus once malaria had been introduced into a suitable locality it might have become indigenous. Usually the circumstances of the locality were not suitable.

### Conclusions

Of the five species of *Plasmodium* which can infect man only *P.vivax* is thought to have been that parasite which caused malaria in Great Britain. Only *P.vivax* gives rise to an illness with a low mortality rate. This was a main feature in those recorded cases of ague which might have been malaria.

There are strict limitations of temperature governing the parasites intra-anopheline life cycle. This will not take place if the temperature falls below 60°F within two



hours after inoculation of the mosquito. At temperatures of approximately 60°F the whole life cycle takes six or seven weeks to complete. Although some immunity is produced in the human host a small percentage of parasites may persist in the human body for at least three years after initial infection.

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#### CHAPTER 4

Malaria - the vectors.

##### Anopheline mosquitoes

Of the two main types of mosquito the anophelines are those which act as malarial vectors for man and for those animals which can contract the disease. Only four species of the anophelines have been found in Great Britain. (1) They are *Anopheles maculipennis*, *Anopheles algeriensis*, *Anopheles claviger* and *Anopheles plumbeus*. *Anopheles algeriensis* is rare and has been found only in Norfolk. *Anopheles claviger* and *Anopheles plumbeus* both live outside, the latter breeding in hollow trees or water barrels. They have both been found in Scotland. (2) (3)

In Great Britain the outside temperature is not suitable for the completion of the intra-anopheline cycle of the plasmodia, for this process will not take place below 60°F. Thus both *A.claviger* and *A.plumbeus* are ineffective as carriers in this country. Furthermore it has been found impossible to inoculate *A.plumbeus* with *P.vivax* even under laboratory conditions. (4)

##### *Anopheles maculipennis*

*A.maculipennis* must have been the malarial vector in



Great Britain. Much of the field work done on *A. maculipennis* was undertaken in those European countries in which malaria existed, and where there were sufficient numbers of infected mosquitoes to study. Such studies took place after the association of mosquitoes and malaria had been recognised in 1898. By that time malaria had virtually died out in Great Britain but was still rampant in the Netherlands and Italy. Dutch workers in the 1920's discovered that this species had two sub-species, *A. m. atroparvus* and *A. m. messeae*. (5) The former roosts indoors and its adult females survive the winter. As it lays its eggs in saline rather than fresh water, it is found in coastal areas only. *A. m. messeae* is an inland though out-of-doors rooster which lays its eggs in fresh water. It is believed not to be a malarial vector in Western Europe although it is the main malarial vector in U.S.S.R. (6) The reversal of roles in this case is probably accounted for by the fact that the coastal waters of Northern Russia are entirely ice-bound for about six months in the year, whereas the inland mosquito breeding areas have a higher mean summer temperature than many places in Great Britain.

#### Infection with plasmodia

Only the *A. m. atroparvus* adult females survive the winter. Malaria is transmitted by the bite of these adult mosquitoes. It is therefore possible that a mosquito infected with plasmodia may survive the winter and be capable of transmitting malaria in the following

spring. However Swellengrebel, investigating this matter in Northern Holland, found very few adult mosquitoes in houses before midsummer. There were unlimited numbers from September until February. In addition he found that viable sporozoites of *P.vivax* were never found in adult mosquitoes between January and August. In the former only in 0.2% and in the latter in 0.1% of insects. These figures rose to 10.2% in October. Investigations covering *A.m.messeae* showed that the numbers with viable sporozoites were never higher than 0.8%. (7) Thus it appears most improbable on this score alone that the ague of the Scottish inland parishes could have been malaria for at least in Holland *A.m.messeae* is a poor vector.

### Zoophilism

Both sub-species are preferentially zoophilic, and both prefer darkness to light. They have a photokinetic response which leads them towards luminosities of lesser intensity. (8) Although they live in human habitations Hackett and Missiroli found in Tuscany that they did not seem to roost in the same place in which they fed. (9) Both there and in the Camargue investigations showed that the majority left their roosts and fed on animals, cows, horses, pigs and even occasionally dogs, and then returned to their roosting places. (10) This preferential zoophilism of anophelene mosquitoes was the characteristic noted by Wesenburg-Lund and led to the discovery of the two sub-species of *A.maculipennis*. (11)



In Northern Italy Hackett and Missirolí found from 10 to 500 *A.m.messeae* in hospital rooms but from 1000 to 5000 per stable in the adjoining farms. (9) In 1868 there had been 2,200 cases of 'malaria' in one town. In 1927 there was one, and none thereafter until 1941 when an unscreened hospital was opened for patients requiring treatment with malaria therapy. Thereafter a few cases were seen outside the hospital but they did not continue. The authors concluded that until the reintroduction of carriers, however temporary, the density of mosquitoes feeding on animals and the numbers of malaria carriers 'was too small to cause one single case'. The same investigators also showed that mosquitoes disregarded human beings in the rooms where the insects roosted but fed on the cattle in the stable underneath. Jancso confirmed this observation in Rumania.

#### Breeding grounds

*A.m.atroparvus* prefers ovipositing in slightly brackish water. There has been some disagreement over the matter of the preference of *A.m.atroparvus* to lay its eggs in salt water. However there seems to be no doubt that the larvae of these mosquitoes can and do survive in water with up to 36 parts per hundred of sea water salinity whereas this concentration kills the larvae of *A.m.messeae*. (1) It is believed by Buxton and Leeson that 'the ability of a mosquito to replenish its body chloride depends on the permeability of four peri-anal papillae. The relative efficiency of this mechanism may



perhaps be the factor limiting the breeding of only certain types of *Anopheles* in slightly brackish water'. (12) (20)

Because of this preference, the roosting areas for *A.m.atroparvus* must lie within a short distance of salt water.

Despite this, Shute found these mosquitoes occasionally as much as 38 miles from the sea. (13)

Nevertheless it is very improbable that *A.m.atroparvus* would have been found in large numbers in the high Lothian coastal areas and more especially inland from there, nor in the hill-top villages such as Abernethy in the Carse of Gowrie. The other sub-species, *A.m.messeae*, certainly would have been found inland and might have bred even in the Highlands. Indeed the *maculipennis* group have been found at Forres. This is situated  $57^{\circ}.37'$  North.

Moshkovski wrote that 'one of the basic problems of malaria control in U.S.S.R. is the limitation of the spread of malaria on large collective farms, peat bogs, etcetera'.

Indeed one decree 'obliges the deduction of the sum of 5 kopecks from the sale of every ton of peat, for the purpose of a fund for malarial control on the peat bogs'.

(14) Thus *anophelene* mosquitoes might also have bred throughout the peat endowed parishes in the Scottish Highlands: even if they did so, no ague was reported from such parishes.

Hackett believed that one of the factors concerned with the dying out of malaria in the Po Valley and the Rhone Delta was that much land had been reclaimed from the sea and thus the breeding grounds for *A.m.atroparvus* had

been diminished and that vector's place had been taken over by the harmless fresh water breeding *A.m.messeae*. (9)

#### Adverse effect of wave action

van Seventer noticed that the larvae of *A.m.atroparvus* could be destroyed by the action of small waves. (15)

Thus although the breeding grounds for this vector in Great Britain are the low-lying plains such as the English Fens and the Tay estuary, it may have survived longer in the former district, where land drainage accompanied by tide control was instituted. The Fen district has an enormous area in which the land is below mean tide level. This area extends inland for 25 miles from the sea. If the influx of sea water was not controlled this area would be more subject to wave influences. The controls minimise wave action but permit the entry of salt water. The corresponding areas in Scotland are very much less. In the Tay estuary this tidally influenced strip is no more than one mile in width. In the Solway area it is two or three hundred yards wide. In neither district are there locks controlling the wave action as there are in the Fens and the Netherlands. Thus the potential breeding areas for the *A.m.atroparvus* in Scotland are relatively small and do not approach many of the parishes in which it is reported that ague was an endemic disease. In Scotland, though not in the English Fens, these areas might have been influenced by land drainage but because of their narrowness might also be subject to damaging wave action.

### Temperature requirements

As a result of the setting up of the Horton Research project in 1925 it became evident that although the ambient temperatures affected the life habits of mosquitoes, yet they fulfilled their life cycle within a wider range of temperatures than the plasmodia did. For example if a mosquito had a blood meal, at 75°F, it would require another in 48 hours. (16) In outside winter conditions it may not feed more frequently than once every four days, the temperature being low enough to retard the digestive process. The larvae succumb to low temperatures and cannot withstand temperatures of 40°F. However, as already stated it is the intra-anopheline cycle of the plasmodium which is more dependent on correct temperatures.

When a mosquito has had a large meal of infected red cells, the parasites therein will start their cycle. This requires not only an adequate temperature but also an energy exchange. The latter is drawn from the host, the mosquito. Thus the insect must constantly renew its energy requirements and must remain for two hours thereafter in a thermal situation in which the ambient temperature is at least 60°F in order to satisfy the needs of the plasmodia. Thus the mosquito in these circumstances feeds every three days though more usually every 48 hours. They are predominantly crepuscular feeders. This habit is thought to be influenced by the total effect of the environmental cycle. At twilight the temperature usually drops; the relative humidity increases and the light not



only decreases in total amount but the wave-length shifts towards the blue-green end of the spectrum. (18)

Mosquitoes are attracted to areas of temperature higher than the surroundings. Thus it can be expected that they will chose to feed on someone in the pyrexial stage of malaria rather than on an adjacent healthy person. The former will of course have parasites in his peripheral blood and the disease may thus be transmitted.

Mosquitoes are also sensitive to raised concentrations of carbon dioxide and also apparently to some particular odours, particularly those associated with animals. (9) (19)

#### Mosquito mortality rate

de Buck and Swellengrebel believed that there was a higher death rate in mosquitoes which had a high rate of infection with parasites than with a lower one. However they stated that this phenomenon was only apparent in the season February to August, which they and James believed to be the non-infective season. (17)

There appears to be some doubt about the longevity of mosquitoes. Many authorities think that there is a geometrical decrease in numbers of 50% per day. (18) Thus even if the minimum time for survival is ten days so that the plasmodial cycle may be completed, conditions for survival and successful breeding of mosquitoes must be first class. However, others including Hackett think the mortality rate is somewhat more than 50% per week.

### Effects of weather

There are two further ways in which weather may influence mosquitoes. Many authorities declare that the temperature of the water in which the eggs are deposited is not of great significance, provided that it exceeds 40°F. Wigglesworth, however, said that *A. maculipennis* prefers water at temperatures between 72°F and 84°F. (19) Such temperatures must occur very infrequently in Scotland. Thus mosquito breeding in Scotland is somewhat circumscribed by temperature limitations.

Secondly it is a general rule that at dusk there is an off-shore breeze in coastal areas and an on-shore air current about dawn. This means that in the narrow coastal plain in the Carse of Gowrie the mosquitoes would tend to be blown out to sea rather than towards the landward areas where the parishes with ague were situated. Such a hazard does not operate to the same degree in areas such as the Fens where the breeding areas were very much wider and much of them were inhabited by potential human victims.

### Possible ecological changes

It is a possibility that *A. m. messeae* was in fact a potential malarial vector in Scotland. However it roosts outside where the temperatures in Scotland are scarcely ever suitable for the first two hours of the plasmodial intra-anopheline cycle. Therefore if it had been a vector there must have been a change in its habits. For example, it might have roosted indoors 200 years ago,



and roosted outside now. Also, as it is deemed to be almost totally zoophagous nowadays, except in U.S.S.R., 200 years ago it might have been more inclined to be anthropophagous. But this preference alone would not have allowed it to become a successful vector unless it had at the same time lived inside where alone the temperatures could have been satisfactory for plasmodial development. It is also a possibility that in the last two centuries *A.m.atroparvus* has changed from being a fresh water breeder to its present status of a salt water ovipositor. If this is the case it is at least noteworthy that such a grave ecological change took so short a time to complete, for ague was said to have appeared, run its course and disappeared within 100 years in Scotland. This was not the case in England. Perhaps the temperatures were more generally suitable there.

Malaria is not caused by the bite of a mosquito, but by the introduction of malarial parasites, maturing in the insect though initially obtained from a human carrier. Mosquitoes may exist in a locality but if there are no plasmodia, or conditions are unsuitable for their development, there will be no malaria.

### Conclusions

The only possible vectors in Great Britain can be the *Anopheles maculipennis* group. *A.m.atroparvus* breeds by preference in salinified water. This confines its egg-laying to the low coastal plains. The larvae are destroyed by wave action. This further limits the breeding



areas, which are restricted in Scotland to narrow bands in the Tay and Forth estuaries and part of the Solway area. They almost certainly cannot include Berwickshire. In contradistinction to *A.m.messeae*, it roosts indoors and its adult females survive the winter. *A.m.messeae* breeds in fresh water and in Great Britain is almost wholly zoophagous. Ambient temperatures are sufficient for the vector's life cycle, but are probably inadequate for that of the parasites.

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## CHAPTER 5

Environmental factors affecting vectors - land reclamation.

It was constantly reiterated by many authors that agues and intermitting fevers were caused by the miasmata arising from undrained marshes. Despite the fact that Hippocrates and Columella had supposed that some fevers might be associated with the presence of mosquitoes, yet the relationship between these insects and malaria was not confirmed until the end of the nineteenth century. It is not surprising therefore that the dying out of ague was related to the drainage of the marshlands and the disappearance of the miasmata. (1) (2)

### Factors necessary for indigenous malaria

The Pontine marshes south of Rome were not drained until the first half of the twentieth century. Until that was done and the breeding places of the mosquitoes were diminished, those marshes were highly malarious areas.

In the Netherlands, the Polders were the breeding grounds for anophelene mosquitoes. During the 1939-45 war the Polders were flooded, restricting the movement of troops and the pasturing of cattle. Until the flooding was once more brought under control and made secure from



the maritime influx, cases of malaria were reported from Holland. The mosquitoes still breed there. The balance in favour of the disappearance of malaria was redressed by an increase in the numbers of cattle which acted as diversionary food supplies. The World Health Organisation did not declare the Netherlands to be a malaria free area until 1970.

The area surrounding the mouth of the Rhône<sup>^</sup>, the Camargue, was made free from malaria during the early twentieth century. Nevertheless anophelene mosquitoes still breed there. When a Polish soldier who was a carrier of malaria was posted there during the war, the disease recurred.

Thus it is apparent that even though land drainage may decrease the numbers of vectors, one essential for the introduction of malaria into an area is the arrival of a carrier as a source of plasmodia. Even if there is such a source the disease may still not become indigenous if there is a plethora of animals as a diversionary food supply for the mosquitoes. If the animals also diminish in numbers the mosquitoes may of necessity become anthropophagous and thus possibly transmit malaria. This is the sequence of events which is believed to have caused the recrudescence of malaria in the Netherlands during the war. Whereas in the Camargue it was more probably the arrival of a carrier. It appears that there were always carriers in the Netherlands before the war. They had

been infected in the Far Eastern Dutch colonies and had carried the parasites back to the Netherlands, where during the war conditions had again become suitable for the disease to become indigenous.

In East Anglia, Essex and Kent malaria was prevalent until the middle of the nineteenth century, and in many districts for several years thereafter. This of course could not be proved until the discovery of the infecting plasmodia. After that discovery the ague of former times could be related to malaria, that disease caused by plasmodia which had been inoculated into the human being by the vector mosquito. It is curious that ague died out in the Solway area 80 years before it did so in the not far distant Morecambe Bay area. This apparent anomaly may be related to the difference in temperatures in the two areas.

#### Doctor Whitley's Report (3)

A report was commissioned by the Privy Council in 1863. Dr Whitley was asked to report on the prevalence of malarious diseases in the marsh districts in England. Scotland was not included. Probably malarious diseases did not occur there at that period. The report showed how common ague had been. The author remarked on its lessening incidence being related to the drainage of some of the fen and marsh districts, though this relationship was not universally agreed. The reporters disagreed at Maidstone 'where the practice of land drainage is almost

unknown' and where 'in the surrounding villages ague had prevailed rather extensively'. The author declared that in some localities ague had arisen since the lands had been drained by ditches.

### Prevalence of ague

It is interesting to compare the figures of admissions to hospitals with ague in any one year. The records are incomplete and it is impossible to find figures for several districts before 1859. Also the total admission figures are not always recorded. However the diversity of numbers over the districts of East Anglia in what Wheatley's reporters all stated was a bad year for ague may be significant.

	<u>Cases of ague</u>	<u>Total admissions</u>
Hoo	61	1400
Gravesend	371	1490
Norwich	4	1000
Peterborough	289	1437
Spalding	98	282
Lincoln	18	-
Hull	31	-
Carlisle	3	2580

Many recorders referred to the very small mortality rate and also to the infrequency of finding splenic involvement.

The very diversity of numbers throws some doubt on the universal agreement of the diagnosis being malaria.



Furthermore all these districts with the exception of Carlisle are in the 'marshland' area.

This appears to agree with the idea that ague had died out in the north of Great Britain by that time. It also agrees in general with the idea that there was a decrease in the prevalence of the disease coincidentally with the increasing 'drainage' of the land. But it is not only the act of drainage that causes malaria to die out nor indeed prevents its return. After the 1914-18 war establishments were set up in the south of England to care for those returning service men who had contracted malaria whilst abroad. By 1921, 500 civilian cases of malaria had been notified throughout the surrounding districts. (4)

#### The Land drainage in Scotland

All these references to places outside Scotland show several different aspects of the problem of the transference of malaria and its endemicity. It is essential that there shall be the correct species of mosquito and in sufficient numbers. Thus there must be appropriate breeding grounds. These can be destroyed or modified by land drainage. Thus the minister of Kirkbean could write 'The ague has almost disappeared. This has been attributed by some to the wet and morass grounds being now entirely drained'. (5) And in Longforgan 'Since the ditches have been deepened and the lands so completely drained of water the disease is scarcely known'. (6) And yet in Edinburgh and the

surrounding district there was no effective drainage of the Nor' Loch until early in the nineteenth century, and until then also there were frequent references to the nuisance of the surrounding irrigated fields. (7)

Notwithstanding this the Statistical Account does not mention ague in Edinburgh. So much was it the case that the Edinburgh marshes had not been drained that Stark wrote in 1827, 'Are the Remittent or Intermittent Fevers more common in those parts of Edinburgh exposed to the assumed malaria from those irrigated meadows than they are in situations remote from their influence?' (8) In the first place he found that ague was unknown. Thereafter he found that the 'Remittent Fevers' were common in the ill-housed areas even though these might have been near the stagnant ditches and meadows such as Hope Park, but they were not associated with the irrigated fields. So the breeding places for some species of mosquitoes remained although the Nor' Loch was said to have been drained 60 years previously. The same story is reiterated throughout the country in the various agricultural reviews written around 1794. The land had been partially but ineffectively drained and in many parts at least half of it remained undrained. (9) (10) (11) (12) (13) (14) (15) (16) (17) (18) (19)

#### Assumed advantages of drainage

As has been noted already, van Seventer drew attention to the ill effects of unrestricted wave action on the larvae of *A.m.atroparvus*. (20) Thus not knowing the method of transference of ague, nor of the specific

breeding requirements of vector mosquitoes, which had anyhow not been recognised, the eighteenth century recorders were not in a position to doubt the accuracy of their allegations that ague died out coincidentally with the drainage of the marshy farm lands of the inland and upland districts of Scotland.

This point is reinforced by Pennant writing about Kelso on a journey made in 1772. '... a vast stretch of country highly cultivated, watered with many stretches of the Tweed and well wooded on each margin. Turnips and cabbages for the use of cattle cover many large tracts; potatoes appear in vast fields. Much wheat is raised in the neighbourhood.' (21) To have achieved all this must imply better farming methods, one of which would have been better drainage of the land. However the records of the Kelso Dispensary show that in the years ending 30th September 1780, 1781 and 1782 there were respectively 73, 156 and 100 cases of ague and intermitting fever admitted to this small hospital. (22) So in this case the implied drainage of the land did little towards overcoming ague in that district.

#### Anopheles maculipennis messeae breeding grounds

The anopheline mosquito which breeds in such inland districts is *A.m.messeae*. Hackett and Missiroli believed that this mosquito was not, and never had been a malarial vector in Great Britain. Indeed when the Pontine marshes were partially drained in Italy and



*A.m.atroparvus* disappeared it was replaced by the harmless *A.m.messeae*. (23) (24) Nevertheless the latter is the chief vector in the U.S.S.R. (25) It had not been understood, until Wesenburg-Lund drew attention to the fact, that there are two sub-species of *Anopheles maculipennis*. (26) Of these *A.m.messeae* is even more preferentially zoophagous than *A.m.atroparvus*. Furthermore, as it lives outside it is most improbable that the ambient temperatures in Scotland would ever have been suitable for the completion of the life-cycle of any plasmodium with which the insect might have been infected. The drainage of inland marsh and farming areas might have destroyed the breeding places of *A.m.messeae* but would not have destroyed those of *A.m.atroparvus*. The problem of reducing the breeding areas of that mosquito are quite different in Scotland from the reduction of such areas in East Anglia and the Netherlands. These problems depend in part upon the area to be drained, its height above mean tide level, and the slope of the ground. Thus the incidence of 'malaria' would not have been affected although it is claimed that the incidence of ague diminished.

#### Further results of land drainage

With the drainage of land, more ground became available for improved agricultural methods. As will be shown hereafter this led to better cropping and thus to more prolific animal husbandry. This in turn might have provided a diversionary food supply for the vector

mosquitoes which still exist despite the land drainage. Such a diversion might have led to the dying out of malaria in a district where it had been indigenous previously, provided always that it had been near the breeding grounds of *A.m.atroparvus*. This cycle of events has already been noted in some European localities after the 1939-45 war.

It is also possible that with more prolific animal husbandry some beasts were kept in stalls adjoining the houses of the farm labourers and there served to raise the temperatures in such potential mosquito roosts. If this is so then agree, if it was malaria, could have died out as a result of the increased availability of animals as food supplies. This does not take into account the fact that 'malaria' could only have been indigenous before that time if there had been sufficient in-dwelling animals to provide the required temperatures. Malaria is not necessarily transferred to a new victim merely because a previous victim has been bitten by a mosquito. The plasmodial intra-anopheline cycle must take place and then a new human being must be infected.

### Summary

The effects of land drainage have been noted in diverse localities. This action will certainly diminish the breeding grounds of anopheline mosquitoes. However those mosquitoes may not live in conditions which are suitable for the intra-anopheline plasmodial cycle to be fulfilled.



Thus this factor may not contribute to the dying out of malaria. The drainage of land in Scotland allowed improved farming methods. Coincidentally ague may have died out. The two matters may not have been linked if ague was in fact malaria inasmuch as the essential factor for endemicity may be that of suitable temperatures.

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## CHAPTER 6

Environmental factors affecting vectors - improved animal husbandry.

Land drainage not only reduced the breeding grounds of mosquitoes, even though those insects were probably the harmless *A.m.messeae* in most cases, but also it improved the soil so that new methods of husbandry might be adopted.

### Lack of fertilisers

At the beginning of the eighteenth century no root crops were grown, and the grain crops produced a miserably small return. Indeed there was a vicious circle. The grain crops were poor and so there was no straw on which to feed the cattle throughout the winter. In summer their feed consisted of the out-field cropping, and in the winter the beasts were sold off. (9) It is recorded of Forfar 'At the end of winter but more especially at the close of seed-time every horse and ox employed on the farm were by hunger and hard work worn to skeletons and not uncommonly had to be lifted on to their legs to help them to the grass fields'. (1) As there was no fertilising manure the fields were constantly being drained of the essential nitrogen and the return for sowing was minimal.

### Introduction of root crops

However with land drainage and with the introduction of turnips from Holland to England in 1716 and thereafter to Scotland the cattle grew fat, and produced the fertilising manure. Thus more and better grain crops were possible and the cattle could be kept throughout the winter.

Twenty years before that clover and rye grass had been introduced, but the local farming population had been suspicious about 'such English weeds'. Similarly Rutherford's turnips helped to produce such large animals 'that people accustomed to stunted animals would not consider eating such monsters'. (2) However such prejudices were quickly overcome.

The same scrutiny was also given to potatoes, and it is recorded that as late as 1740 'two sackfuls on a market day supplies the demands of the five thousand inhabitants' of Paisley. (3)

### Field enclosures

When the benefits of these introductions were apparent, it became desirable to enclose the fields thus preventing the access of marauding cattle. These enclosures were done either by walling, which had the added benefit of clearing the stones off the field surfaces and making cultivation less hazardous, or by planting hedges and shelter belts of trees. These innovations were also viewed with suspicion by many persons who supposed that the extra growth of trees would take away the goodness from



the ground and their crops would be diminished. Once more the prejudices were overcome.

### Goat keeping

Until then goats had been kept, partly for their milk and eventually for their flesh, but also for their skins. It is recorded that 100,000 goat and kid skins were sent into England in one year. (38) Goats do not need especial food as cattle do, but they do destroy growing hedges and young wood. Thus goats became less commonly kept in the Lowlands. However it is recorded that they remained common in the Highlands where Dr Johnson called at 'a house in which a lady kept a herd of over sixty goats'. (4) Indeed they were kept especially in places such as Cabrach. Patients were sent there for the benefit of the goat's milk which was believed to cure consumption. (5) Furthermore a special variety of goat was imported from America. Such goats produced two litters each year and of course an increased amount of milk as well. (6)

### Cattle husbandry

With the increased farming prosperity not only were the farm servants allowed to retain their own cows occasionally, but the farm owners could improve their farm buildings with the increased rentals they received. (1) (7) Thus instead of the cattle being fed on the poor outfield in summer and being sold off in winter, they were now housed in special 'hammels' and fed on the root crops in winter. Besides the summer crops were also of much better quality. (8) (9) (10) Thus the animals were no longer

housed in close proximity to their owners. Furthermore in summer they were outside, at least during the night.

Evidence has already been given that mosquitoes do not necessarily roost where they have fed. Furthermore it has also been noted that if they roost in a human dwelling which is in close proximity to animal houses they will feed in the latter. (37) And once more it is reiterated that the malaria vectors of Great Britain are preferentially zoophagous.

#### Mosquito zoophilism and animal heat production

This new aspect of animal husbandry is remarked on in all the Agricultural Reviews of the period. No longer could cattle be regarded as being in such close proximity to human beings at any time of year that they could raise the temperatures in their dwelling places to the critical temperature for intra-anopheline plasmodial development. Furthermore even if one supposes that in any area the numbers of cattle were insufficient to provide a diversionary food supply and as a result human beings were attacked, the cattle were not housed in the former's dwellings to augment the temperature. (14) (15) (16) And if there had been a sufficient number of cattle, then the human beings would not have been attacked. Indeed mosquitoes may, and often do, roost in animals' houses, but with their preferential zoophilism will not go forth and feed on human beings.

During the eighteenth century when ague was said to have been prevalent, there were certainly fewer cattle than

there were at the end of the century when it died out. However it seems very improbable that sufficient numbers were kept inside the farm-hands' houses to provide the requisite temperature change; and if the numbers had been sufficient for the latter purpose they would have provided the mosquito's food source.

It is possible that pigs were kept in close proximity but the records imply that they were in insufficient numbers to provide the required heating augmentation. The same comment applies to goats, although they were more numerous in the Highlands where no ague had been reported.

#### Farm animals as ague vectors

It is true that ague died out about the time that there was this great improvement in animal husbandry. However it may have done so not because the increased cattle numbers provided diversionary food supplies for the hypothetically infected malarial vectors, but because the farm animals were not so closely tended by the labourers and their families on the steadily improving farms. The farm animals themselves might have been the carriers of the source of the ague, for some of those with ague might have had brucellosis.

#### Farm labourers' cottages

Mosquitoes prefer roosting in darkened, warm, draughtless rooms. The Agricultural Review for Angus had recorded, 'It is within the memory of the present writer that the farm-houses were wretched hovels made with stone



and turf alternatively and covered with turf and a film of straw when this could be spared from the cattle feed.

The farmer and his wife were in coarse blue rags. The whole family are obliged to sleep on a damp soil the floor not being so much as paved and often without a fireplace'.

(17) 'There were seldom any windows nor a chimney so that the smoke from the ever-burning peat fire escaped however it could.' (18) Indeed Burt said he could not see across the room for the smoke. (19) Such a dwelling could never be used by mosquitoes. If in fact such houses had been mosquito roosts, with earth floors and no windows it is extremely improbable that the farm labourer's cow could have raised the temperature to such a degree as would permit the plasmodial development to take place.

### Farm animals

Although pigs did exist near the human dwellings, it seems that until the end of the century there was a prejudice against eating such animals. So their numbers were probably not large. Furthermore because they are not covered with hair they are not efficient 'sty-warmers'. Until the last quarter of the century cattle were kept for their value as beef and not for their milk. In general the country people did not drink cow's milk and certainly did not eat butter. This was largely used for 'treating' the fleeces of the steadily increasing numbers of sheep. Robertson of Ladykirk wrote of his cottars, 'Their highest notion of living is to obtain milk and meal'. (20) And other writers remark on the scarcity of milk. (21) (22) (10)

The keeping of goats has already been noted. Horses were certainly kept, but not in sufficient numbers to influence the matter under review.

### Meat supplies

The demand for meat in the cities in the latter half of the century is illustrated by the numbers of animals slaughtered in Edinburgh in 1775. 'There were 8,354 oxen; 6,792 calves; 39,370 sheep and 47,360 lambs. The numbers of hogs and pigs cannot be ascertained.' (23) This was for a population of 80,000 persons, Exactly 200 years later the population was six times greater. In Edinburgh in 1975, 42,312 oxen; 1,137 calves; 164,706 sheep and lambs were slaughtered, together with 44,449 hogs and pigs. These figures show the large amount of meat consumed in the eighteenth century. However this was the capital city of Edinburgh. It may not have been the same story in the countryside.

### Town cattle byres

There were a great many cattle byres in the city in the mid-nineteenth century. Littlejohn reported that in 1857 there were 171 byres containing 729 cows in the city north of Princes Street and 1,068 beasts to the south. One hundred and sixty one of those byres were situated under a dwelling house and were 'altogether a nuisance'. (24) It may be that ague died out in Edinburgh as a result of the influx of milk cows thus altering the human/animal relationship and influencing the mosquitoes' eating habits. However this is almost certainly not the case for the

following reasons. Littlejohn's report implied that there were many cow-byres in the old town, and 171 had already been built in the new town. Thus with the growth of the new town at the end of the eighteenth century it is slightly improbable that cows supplying milk would have come in increasing numbers into the old, rather than the new town. The new town was where the consumers of that comparative luxury lived. Nevertheless the 'Shambles', the abattoir still existed on the shores of the Nor' Loch and presumably this was where the beef cattle were housed.

Thus the increase in numbers of resident cattle was largely in the new town. So if there had been malaria there it would have tended to die out. But as the years passed more and more cattle were kept in the fields surrounding the town, and at length communications improved so greatly that milk was brought in daily from the surrounding country farms. Thus the proportion of cows to humans diminished in the old town in the 1790's and in both parts of the city in the mid-nineteenth century. It has proved impossible to find any records of pigs being kept in the city. They are not even shown in any coloured 'prints' of the period. They too would have acted as diversionary food supplies for mosquitoes.

The New Statistical Account written in the mid-nineteenth century alleges that ague had died out from Edinburgh by the end of the previous century. However the 'Old' Statistical Account written then makes no mention of ague having been present in the city.



If the 'Old' Account is wrong and the New Account is correct, even with the movements of cattle at the end of the eighteenth century, and in the mid-nineteenth century as a result of Littlejohn's report, ague was not provoked to return to the city. Even by the latter date the marsh areas had not been fully drained. However neither factor might have made any difference if ague had been present for there were no saline marshes within the immediate vicinity of the city as it then was thus there were no breeding grounds for *A.m.atroparvus*, and thus malaria could not have been indigenous.

#### Sheep farming

Towards the end of the century there was a switch from keeping cattle to keeping sheep whenever it had been realised that the latter could withstand the rigours of winter weather outside. From 1757, 150,000 sheep were sent across the border to England each year. Furthermore as a source of income they could be herded and sold more readily than cattle which had to be driven to the trysts, or even further into East Anglia. Also the sheep's fleeces were increasingly used for the newly expanding wool markets.

#### Cattle diseases

There are very few specific mentions of cattle disease. (25) Youatt remarks on the incidence of 'rinderpest' in England from 1745-1757. (25) This provided a boost for the export of cattle from Scotland. Many of these were required for provisioning the navy, and records exist of the numbers of Scots cattle required for this purpose. (26)

### Contagious abortion in cattle

There are no records of 'slipping the calf' on the droves. This is strange if contagious abortion had been as prevalent as it was in England. It was recorded in England by Vancouver in his review on agriculture in Cambridgeshire (27) and by Youatt (28).

However there may be an explanation of this apparent anomaly. Large numbers of cattle were imported from Ireland each year. In the period 1786-1790, 55,000 were imported through the harbour of Portpatrick alone. (29) These cattle were dispersed over the country and fattened as far as possible for the droving trade to England. They were often bought in by the Lowland farmers and fattened up there for the markets after the Highland farmers had disposed of them. They were seldom kept for more than two years having produced one calf in that time. There is a folklore tale which exists into the present day that herds of cattle were always accompanied by a billy-goat. The idea was that the goat which might be infected with 'brucellosis' would infect the cattle with Br.abortus. Thereafter the cattle would 'drop' their first calf but having done so would develop some immunity to the disease. The accompanying goat would be unaffected. If there is any truth in this, and certainly goats did accompany herds of cattle, then many of those cattle which had developed brucellosis might have passed on this disease to those by whom they were attended, the farm labourers.

Although brucellosis has been shown to be transmitted

by goats<sup>1</sup> milk in some countries, it has not been thus incriminated in Great Britain. If the goats had been thus infected, as they were kept in large numbers in the Highlands, one might have expected that brucellosis, an ague-like disease, might have been reported from those areas. It was not recorded in those parishes. On the other hand the cattle imported from Ireland might have been infected already - but being beef cattle would only have passed on any infection to those coming into contact with them during and after calving. This may not have been a very common occurrence.

#### Rabbits and tularaemia

There is another matter worth considering. A report from Barrie states that 'Rabbits were bred in large numbers'. (31) This almost certainly should be interpreted as meaning 'Rabbits bred in large numbers'. In addition a later report from Dowally in central Perthshire shows that 125 dozen rabbits were killed each year at the end of the eighteenth century and their skins were sent to the expanding fur market in Dumfries. (32) And at Stromness in one year 36,000 were killed and sold at 8d each. (33) These extracts imply that there were large numbers of rabbits and that they were handled no doubt for food as well as for their skins. Rabbits are in the same category as lemmings and can transmit tularaemia.

It is not suggested that all the agues of the farming communities in Scotland were in fact tularaemia or brucellosis. However some of them may have been.

#### Housing the humans

With the improvements in animal husbandry throughout the century, there was an increase in the diversionary food



supplies for mosquitoes. This would have been a factor in causing previously established malaria to die out. However with the increase in cattle numbers, an improvement in housing conditions also took place. It was not that there was a sudden abolition of all the crude and insanitary dwellings throughout town and country, rather it was a separation of animals from human dwellings. In this case the animals were no longer present and able to raise the temperatures of the dwellings to the critical level for plasmodial development. Such a factor is essential if malaria was to have been indigenous in Scotland where the ambient temperatures are not suitable for this cycle to take place.

#### Overcrowding and the spread of disease

However even if ague was not 'malaria', and there is no reason to doubt that agues existed in the communities, the housing conditions were still so bad that Littlejohn (24), Wilson (34) and Stark (35) and many others drew attention to the gross overcrowding and insanitary conditions in the towns. Indeed it was this overcrowding that was no doubt responsible for the spread of such diseases as smallpox and tuberculosis; measles and whooping cough and diphtheria. The conditions would also have been favourable for the spread of influenza. Even as late as 1861, 7,964 families in Scotland were living in a single room. (36)

#### Brucellosis in man

It has been reiterated that agues and intermitting fevers were commonly the diseases of farm labourers and not of the well-to-do. Throughout the country there was a

dramatic increase in the numbers of cattle kept and handled. They might have transmitted brucellosis to their handlers. This may be transmitted by drinking infected milk or by handling the various dejecta. During the winters if any cattle could be kept they would be giving minimal amounts of milk. Only in springtime and with better cropping would the milk supply increase, and perhaps it increased enough over the years to allow the families of farm labourers to drink it. Thereafter sheep took the place of cattle. Dairy herds were concentrated on the towns and only when communications improved was there a return of dairying on a large scale in the countryside.

Goats on the other hand were gradually banished from the Lowlands about the time that ague died out.

In other countries though not in Great Britain, both pigs, sheep and goats have been incriminated as carriers of the organisms causing brucellosis. Perhaps there has been a change and all the organisms causing human brucellosis were at one time present in Great Britain. However sheep are not frequently handled and do not act as milk sources. Pig farming certainly increased towards the end of the century and pigs can act as food supplies for mosquitoes; indeed they could also be responsible for raising the temperatures of their sties above the ambient temperature level if kept in sufficient numbers. However as time went on they too were banished from the human dwellings. Ague did not return.

### Animal husbandry and ague

It is arguable that as animals were dispersed away from human habitations so also diminished the possibility of having indigenous malaria. The animals were no longer there to increase the house temperature to the requisite level. In warmer climates this is not a factor in the dying out of malaria for the temperatures are adequate for plasmodial development without the increment from the animals. Equally it is arguable that in Scotland with increasing numbers of cattle being kept, and more dairy products being available, if brucellosis had been widespread amongst the animals it might have increased the amount of the same disease amongst their attendant farm labourers. In fact ague, whether or not it was malaria, or brucellosis, was said to have died out coincidentally with these changes.

### Present day prevalence of brucellosis

It is evident that brucellosis is still prevalent in the British Isles. In 1977 it has been recorded that it was considered to be endemic 'in at least four counties in the south-east region of Ireland. In the years 1972-1975 inclusive, the hospital serving those counties yielded 1,332 sero-positives, many to a very high dilution. The numbers of new sero-positives increased sharply each year.' (30)

### Conclusions

In order that malaria shall become endemic in any area one of the essential factors is the provision of a



temperature suitable for the intra-anophelene development of the plasmodia. Without some augmentation the ambient temperatures are almost never suitable in Scotland. By reason of the inadequate house construction the only way the temperature could have been augmented would have been by the presence of several animals. Even this is improbable because the houses were earth-floored and often windowless and thus did not conserve heat, and were filled with smoke which is not congenial to mosquitoes. It appears that there is a level of relationship between the numbers of animals and humans in any area above which level the mosquitoes will always indulge their zoophilic preference. Thus malaria may die out when that plethora of animals is reached, or return when the relationship is more nearly equalised. With the increasing numbers of cattle kept in Scotland as a result of more effective husbandry, malaria might have died out because of the diversionary effect of the animals, but also it would have died out because the animals were thereafter kept away from the labourers' houses and were thus not present to raise the temperatures therein, even if this had ever been possible in the circumstances.

Ague might also have been influenza sometimes and this would certainly have spread into epidemic proportions because of the housing situation. It might have been tularaemia sometimes and it might have been brucellosis carried, probably by the cattle, but not impossibility by one of the other farm animals.

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## CHAPTER 7

Environmental factors affecting parasites and vectors -  
temperature.

### 'Mean' temperatures

The majority of published temperature recordings are made as 'means'. These mean figures fluctuate with the occurrence of an exceptionally high maximum, or an unusually low minimum. The mean does not give a true picture of the day's temperatures, and an even less true one of the month's figures. Nevertheless, to relate one set of means to another over a long period at least makes comparisons possible.

### Significance of outside temperature readings

Nowadays temperatures are recorded outside in an especially constructed box. Thus they do not record temperatures which are strictly relatable to the inside of human dwellings 200 years ago, nor to the cow-byres and pig-sties of any era. However, as *A.m.messeae* lives outside in summer, and cannot be a vector in winter because it hibernates, the outside temperatures will be adequate to determine the possibility of the plasmodial cycle occurring in any area with that mosquito as vector.

### Circumstances surrounding the critical temperature

A.m.atroparvus lives inside some form of habitation during the whole year. Therefore it can be surmised that if an ambient temperature of 60°F can be maintained for a sufficient period then malarial transmission is a possibility in that area. However this critical temperature must be achieved for two hours, according to some authorities, and for 24 hours or more according to others. In each case the temperature must be correct immediately after the mosquito has had its blood meal. (1)

Thus the mean temperatures are not satisfactory guides. Temperatures recorded at mosquito feeding time, that is to say about one hour after sunset, until one hour before sunrise, are significant. Alternatively satisfactory conditions exist if the daily minimum temperatures never fall below 60°F. However if the ambient temperatures fall short of the critical one at the necessary times of day, and for the requisite number of hours, it is possible that the gap may be bridged by the heat given out in a circumscribed space by bodies whose innate temperatures are higher than those of their surroundings. Probably the 'night' mean will be several degrees lower than the 24 hour mean and the temperature one hour after sunset.

A series of figures produced by the Meteorological Office for Scotland have been examined. (2)

### Exact locality of official recording stations

These figures are not relatable to all the parishes



in which ague was prevalent 200 years ago. Nor indeed are the figures for Dundee exactly relatable to those of neighbouring Glendoick. Equally the recording station at the latter is not the resting ground for all the blood-satisfied mosquitoes of the Carse of Gowrie.

Thus conclusions must not be drawn about the thermal suitability of various potential mosquito breeding grounds in the eighteenth century from temperatures recorded at Turnhouse in the summer of 1976. However, there may be other pointers.

#### Temperature and the plasmodial life-cycle

It has already been noted that the intra-anophelene cycle of *P.vivax* lasts 53 days at a mean temperature of  $59^{\circ}\text{F}$  according to Jancso, although Wenyon declared that in the Balkans the cycle took 40 days at  $62^{\circ}\text{F}$ .<sup>(3)</sup> These figures do not indicate whether the ambient temperature must never fall below that point for the whole period. This is probably not the case. However the figure must equal or exceed the critical ' $60^{\circ}\text{F}$ ' for the time it takes exflagellation to occur. Some say that this takes 15 minutes. Alternatively Jancso believes that the critical period is one or two hours at the end of which the ookinete should have penetrated the insect's stomach wall. Grassi believes that the temperature shall not fall below  $63^{\circ}\text{F}$ . Broadly speaking the temperature must be preserved at at least  $60^{\circ}\text{F}$  for two hours after the mosquito's infected blood meal. <sup>(4)</sup> Buchan produced mean monthly temperature records for 270 stations in England and

Scotland from January 1857 to December 1880. One hundred and thirty two of these stations were in Scotland. None had a mean monthly temperature as high as  $60^{\circ}\text{F}$ . In contradistinction 105 out of the 138 stations in England had two months consecutively with a mean temperature of or above  $60^{\circ}\text{F}$  and 14 of them had such a temperature for the three consecutive months, June, July and August. (5)

The highest Scottish figures of  $59^{\circ}\text{F}$  were at Pitlochry and Rothesay in July. However it is also true that Pitlochry had a mean the previous month of  $56.3^{\circ}\text{F}$  and of  $57.9^{\circ}\text{F}$  the following one. Thus it is improbable that in those three months, June, July and August, there were several consecutive days during which the temperature remained for long periods above  $60^{\circ}\text{F}$ .

It is possible that the monthly means have altered over the last 100 years. Nevertheless reference to Table A will show that in only three places in Scotland has the figure altered by more than  $1^{\circ}\text{F}$  throughout the summer months in the two periods. The greatest difference is at Wick. In the period 1857-1880 it was warmer there in June and July than it was in 1921-1950. Even so the warmer period had a mean only of  $56^{\circ}\text{F}$ .

It gives a truer picture to quote the means year by year, and Table B shows these for July and August in Edinburgh. (6) These figures are taken as a mean of the maximum and minimum throughout the day. Alongside them

TABLE A

Mean monthly Temperature Averages in degrees Fahrenheit for Period A: January 1857 to December 1880; Period B: January 1921 to December 1950, (Note the figure for Norwich A in October is presumably a misprint in the original and should read 48.6) for comparison.

Place and height above sea level		Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
<u>Dundee</u>													
	A	36.9	38.6	40.2	44.7	49.1	55.3	58.4	57.7	53.6	46.9	40.4	37.9
	B	37.5	38.5	41.2	44.8	49.4	55.3	59.0	57.9	54.0	47.9	41.7	39.0
<u>Dumfries</u>													
	A	37.9	39.3	40.6	45.5	50.2	56.4	58.9	58.5	54.2	47.8	40.9	38.7
	B	38.3	38.9	41.7	45.2	50.5	55.8	58.9	58.1	54.2	48.4	42.3	39.4
<u>Edinburgh</u>													
	A	37.4	39.0	40.1	45.1	49.2	55.7	58.3	57.5	53.5	46.6	40.1	38.2
	B	38.7	38.8	41.3	44.5	49.1	54.9	58.5	57.6	54.1	48.4	42.8	40.1
<u>Kelso</u>													
	B	36.9	38.0	41.1	44.8	49.8	55.4	58.7	57.5	53.5	47.6	41.1	38.4
<u>Perth</u>													
	A	37.3	38.5	40.2	45.1	49.9	55.8	58.7	57.7	53.3	46.5	39.9	38.1
	B	37.2	38.4	41.5	45.5	50.6	56.3	59.7	58.1	54.2	47.9	41.2	38.5
<u>St Andrews</u>													
	A	38.2	39.0	40.8	44.7	49.1	55.1	58.0	57.7	54.0	48.0	41.4	39.5
	B	38.2	39.0	41.4	44.8	49.0	54.8	58.5	57.6	54.1	48.5	42.2	39.7
<u>Wick</u>													
	A	37.9	38.7	39.9	43.8	48.0	53.1	56.0	55.3	52.3	46.5	41.0	39.0
	B	38.9	39.1	40.6	43.0	46.6	51.0	54.8	54.5	52.1	47.6	43.0	40.5
<u>Dover</u>													
	A	39.8	41.6	42.1	47.5	52.4	58.8	62.7	62.4	58.7	53.0	44.0	41.0
	B	40.7	40.7	43.3	47.9	53.2	58.3	62.3	62.3	59.4	53.2	46.3	41.8
<u>Kew</u>													
	A	38.8	40.6	42.2	47.7	52.6	59.0	62.9	61.8	57.2	50.2	42.5	40.0
	B	40.1	40.4	43.8	48.3	54.3	60.2	63.8	62.8	58.3	51.2	44.5	40.8
<u>Norwich</u>													
	A	37.5	39.6	41.8	47.5	52.7	59.3	62.6	61.9	57.6	58.6	42.5	38.8
	B	38.6	39.3	42.9	47.3	53.2	58.7	62.8	62.1	58.1	50.9	43.7	39.3



have been placed the monthly means taken at 08.00 hours at the same station during the same period. (7) This moment is more than four hours after sunrise for most of July and more than three hours for most of August. These are significantly higher than the 'whole' daily mean. This must imply therefore that the nights, the time that the temperature is critical for the plasmodial cycle, are cold enough to lower the daily mean below the critical  $60^{\circ}\text{F}$  even though this temperature is often exceeded during the hours of daylight. Indeed the highest mean temperatures taken in Edinburgh before sunrise during the years 1788-1810 were for June,  $54.6^{\circ}\text{F}$  in 1798; for July,  $57.4^{\circ}\text{F}$  in 1797; and for August,  $55.6^{\circ}\text{F}$  in 1789. (8) However Mossman expressed some doubt on the reliability of these figures for the mean figures over the period 1788-1810 were June,  $50.5^{\circ}\text{F}$ ; July,  $53.4^{\circ}\text{F}$  and August  $52.7^{\circ}\text{F}$

TABLE B (6) (7)  
(D.M. Daily Mean) (08.00 Mean Temperatures at 08.00 hours)

<u>Year</u>	<u>July</u>	08.00	<u>Aug</u>	08.00	<u>Year</u>	<u>July</u>	08.00	<u>Aug</u>	08.00
	<u>D.M.</u>		<u>D.M.</u>			<u>D.M.</u>		<u>D.M.</u>	
1764	59.9	61.4	57.6	59.0	1771	57.4	59.6	56.3	57.7
1765	58.5	60.1	56.8	58.1	1772	58.0	59.8	57.4	58.5
1766	58.9	60.6	59.5	60.9	1773	56.2	58.8	59.3	59.4
1767	56.4	58.1	59.8	61.2	1774	56.8	58.5	56.7	58.3
1768	58.3	60.0	58.7	60.1	1775	59.7	60.2	57.5	58.7
1769	60.1	61.8	56.3	57.7	1776	59.6	60.5	56.7	57.8
1770	57.1	58.6	58.2	59.6					

(See also Table H)

In 1975 which was generally regarded as a hot summer, in Edinburgh on only three days did the temperature remain above 60°F for 24 hours continuously.

So the charts of daily, monthly or annual means merely give an indication of the general trend. The significant times and periods at which the critical temperature must be attained are for the period after sunset; perhaps for one or two hours, or as some think for 24 hours on end. Such figures were not generally recorded in the eighteenth century.

#### Modern thermographic records

Modern thermographic records automatically annotate the outside temperatures every half-hour throughout the year. (2) The graphs for the years 1945-1966 at Turnhouse and the significant findings therein are shown in Table C. This sets out the occasions and times of the day at which the temperature remained at 60°F or above, in excess of 24 hours. According to some this is the period during which the temperature must remain above 60°F.

TABLE C

<u>Year</u>	<u>Date and hour starting</u>	<u>Date and hour stopping</u>	<u>Total hours</u>
1947	July 12th 22.00	July 14th 20.00	46
1948	July 28th 08.00	July 29th 22.00	38
1948	July 30th 08.00	Aug 1st 23.59	64
1949	July 10th 19.00	July 12th 04.00	33
1949	Sept 3rd 22.00	Sept 5th 04.00	30
1951	Aug 2nd 22.00	Aug 4th 23.59	50
1952	June 28th 22.00	July 2nd 20.00	94
1955	July 14th 06.00	July 15th 20.00	38
1959	July 2nd 07.00	July 4th 22.00	63
1959	Aug 23rd 03.00	Aug 26th 03.00	72
1964	July 12th 09.00	July 14th 22.00	61
1964	Aug 3rd 07.00	Aug 5th 20.00	61
1966	Sept 2nd 08.00	Sept 3rd 19.00	35

There were 22 such periods of more than 24 hours consecutively.

#### Post-sunset temperatures

In Table D there is set out the numbers of days in a year in which the temperature in the Edinburgh district exceeded 60°F one hour after sunset during the months June to September thus satisfying James' criterion of one to two hours, which was coupled with the crepuscular feeding times of mosquitoes. There may have been occasional such evenings outside those months. Also it should be noted that the time has been reduced from two hours after sunset to one. The figures would have been lower if the former criterion had been adopted.

TABLE D

1945 1 night	1952 5 nights	1959 7 nights
1946 None	1953 3 nights	1960 2 nights
1947 6 nights	1954 2 nights	1961 3 nights
1948 5 nights	1955 6 nights	1962 1 night
1949 7 nights	1956 1 night	1963 2 nights
1950 None	1957 2 nights	1964 6 nights
1951 3 nights	1958 3 nights	1965 1 night
		1966 2 nights

This amounts to 68 occasions in 22 years.

It may be objected that the figures quoted so far are not relevant for the Carse of Gowrie. Although it has not been found possible to search the thermographic records for Leuchars, the nearest station to Dundee at which they were made, except in the years, 1956-1970, it is reasonable to suppose that the figures here have altered as little as they have elsewhere. (9) The following Table E is relatable to Table C for Edinburgh; and Table F randomly



chosen, is comparable with Table D.

TABLE E

Times of day and periods during which temperatures continuously exceeded 60°F at Leuchars for 24 hours or more.

<u>Year</u>	<u>Date and hour starting</u>	<u>Date and hour stopping</u>	<u>Total hours</u>
1956	July 24th 08.00	July 26th 20.00	60
1959	July 5th 06.00	July 6th 23.59	42
1959	Aug 5th 06.00	Aug 6th 22.00	40
1959	Aug 22nd 04.00	Aug 26th 20.00	112
1966	Aug 16th 08.00	Aug 17th 20.00	36
1966	Sept 5th 08.00	Sept 6th 18.00	34
1967	July 25th 20.00	July 26th 23.59	28
1968	June 29th 04.00	July 1st 20.00	64
1968	Aug 21st 07.00	Aug 23rd 02.00	43
1969	July 19th 06.00	July 23rd 04.00	94

TABLE F

Number of occasions per annum on which temperatures of 60°F or above were recorded one hour after sunset at Leuchars.

1959	20 nights	1964	8 nights
1960	1 night	1966	7 nights
		1969	18 nights

There was seldom a significant number of days beyond the days shown in Table E above on which the one hour before sunrise figures exceeded 60°F.

Temperature records at Leith 1826-1827

Brewster noted the hourly temperatures at Leith Fort throughout the years 1826 and 1827. (10) His findings, Table G, show that the temperatures only exceeded 60°F during the hours noted.

TABLE G

<u>1826</u>		<u>1827</u>
11.00 - 19.00	June	14.00 - 17.00
11.00 - 19.00	July	09.00 - 20.00
10.00 - 20.00	August	12.00 - 17.00

Furthermore taking the figures for one hour before sunrise and one hour after sunset during the same months and years, the mean temperatures at those times are shown in Table H.

TABLE H

1826

June	3.00 a.m.	51.3	10.00 p.m.	55.9
July	3.00 a.m.	52.8	10.00 p.m.	55.7
Aug.	4.00 a.m.	55.4	9.00 p.m.	59.4
Sept.	5.00 a.m.	51.8	9.00 p.m.	54.8

1827

June	3.00 a.m.	51.0	10.00 p.m.	53.6
July	3.00 a.m.	54.8	10.00 p.m.	58.2
Aug.	4.00 a.m.	52.7	9.00 p.m.	56.7
Sept.	5.00 a.m.	55.5	9.00 p.m.	57.3

All these tables, C, D, E, F and G record temperatures in the nineteenth or twentieth centuries, and are therefore not strictly relatable to the eighteenth century. However it has been shown before that over a wide range of country the means have not altered during the last 100 years in a degree significant to the matter under review. Furthermore such detailed figures are not available for the eighteenth century.

Frequency of suitable temperatures

The temperatures are relatively stable for any locality over the period under consideration. If a mosquito had fed on infected blood an hour after sunset on the first thermally suitable day at Turnhouse in June 1952, in the view of Jancso it would have been July 28th before that mosquito was capable of transmitting malaria to any other person. Moreover there could have been no

further intra-anophelene development that year, at Turnhouse, because the critical temperature was never again reached after sunset.

There were few days in any year in any of the quoted localities when the temperatures were adequate for successful plasmodial development. The temperatures before dawn are usually the lowest of the day. In Scotland about  $56^{\circ}$  of latitude north, the post-sunset temperatures do not drop with such dramatic suddenness as they do in the tropics, yet there the air is so warm that the night temperatures are still constantly sufficient. Outside in Scotland this is not the case.

#### Isotherm charts of seas around British coasts

Continental mean temperatures are believed to be higher than the Scottish ones because the former are the temperatures of locations on the continental land mass which tends to retain warmth. Quoted Scottish figures are from towns on the shores of a relatively small island and are thus lowered by the invariable proximity of the sea. Isotherm charts of the seas around the coasts of Great Britain showed that the  $59$  isotherm covered the largest area of the Morecambe Bay complex. However the  $61^{\circ}$  band went close inshore at that point. The shores of Kent and Essex and Suffolk, as far north as Lowestoft, were in the  $63^{\circ}$  isotherm. Whereas the whole east coast of Scotland was washed by seas at  $54^{\circ}$ . This circumstance was recorded for the dates Thursday, 2nd October 1975 - Monday, 6th October 1975.



### Laboratory findings and naturally occurring phenomena

The temperature requirements for the completion of the intra-anophelene cycle of *P.vivax* were first correctly observed when the observations were made under laboratory conditions. These conditions included steady temperatures, though at differing levels, Thus it could be observed how long the cycle did take under varying circumstances. Throughout the natural cycle it is not known with certainty whether the figure must be a 'mean' temperature with fluctuations both below and above 60°F, or whether that figure is one below which it must not fall. The former condition can be realised daily in the tropics, and in the summer months around Rome. It is never realised outside in Scotland for there are never seven continuous weeks in which the temperature does not fall below 60°F.

The temperatures necessary for the life cycle of the mosquitoes are still adequate, for there are still mosquitoes of the appropriate breed to be found in Scotland. Thus the fact that the winter 'means' fall below 37°F is of no significance. The problem is whether the ambient temperatures could be raised to and maintained at the critical level for the intra-anophelene plasmodial cycle, at some period in the year.

### The effect of 'room' temperatures of in-dwelling animals

It has frequently been noted that mosquitoes prefer to roost in small, dark animal houses such as pig-sties and cow-byres. In such confined spaces the presence of warm-blooded animals may raise the temperature of the sty

significantly above the surrounding air temperature. But for the most efficient results the sties should be insulated. It is improbable that effective insulation against heat loss was used by Scottish farmers in the eighteenth century.

Maximum and minimum temperatures: May-October 1931-1960

Dundee

The following Meteorological Reports for conditions in the Dundee area are for the period 1931-1960. The lowest temperature at which the cycle takes place is 60°F. This table shows the average daily maximum and minimum figures in the months detailed.

<u>Month</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Mean</u>
May	57.9	42.3	50.1
June	63.7	47.7	55.7
July	66.9	51.4	59.1
August	65.6	50.7	58.1
September	61.7	46.9	54.3
October	54.7	42.1	48.4

Mosquitoes feed after the sun has set, i.e. after the maximum temperature has been recorded.

Timing of diurnal temperature gradients

The temperature one hour after sunset is usually below the maximum of the day. Indeed it approaches the minimum figure which is reached usually about an hour before dawn. Therefore the above figures have their 'mean' raised higher than the temperature is likely to be just after sunset. This is borne out by Table H which showed the figures at Leith Fort for the hours before sunrise and after sunset.

They do show that at those times the highest mean was  $59.4^{\circ}\text{F}$  in August 1826, in which month the pre-dawn figure was  $55.4^{\circ}\text{F}$ . This implies that there was a decline of  $4^{\circ}\text{F}$  in temperature over the seven hours of darkness during which time the essential  $60^{\circ}\text{F}$  had to be maintained. In one month the difference was as much as  $8^{\circ}\text{F}$ .

#### Mean nocturnal temperatures

If the temperature necessary for the exflagellation process is the critical one, then it must be attained within an hour, or at most two hours, after the insect has had its meal of plasmodia-infected blood. Thus the mean figure between sunset and sunrise is important. The figures for Edinburgh in 1826-1827 varied between  $52.3^{\circ}\text{F}$  and  $57.9^{\circ}\text{F}$ . However modern thermographic records for Leuchars, Table E, show that there were only 23 days in 15 years during which the temperature was  $60^{\circ}\text{F}$  after sunset and also before dawn. This suggests that the natural weather conditions were not suitable for the necessary life processes of the *P.vivax*.

#### Ability of in-dwelling animals to raise room temperatures

So the critical question is whether the presence of cattle or pigs or horses can raise the temperature of their stables four or five degrees Fahrenheit above that of the surrounding air so that the interior of their 'house' is at least at  $60^{\circ}\text{F}$ . The ability to do this does not depend wholly on the body temperatures of the animals concerned, for there is some degree of gradient from the higher to the lower point. As the human body is nearly  $40^{\circ}\text{F}$  above the



critical figure it might be supposed that a congregation of humans would also raise the figure to an acceptable level. Probably this was never possible in a draughty, windowless, earth-floored structure. Furthermore it is noteworthy that even in modern times with modern heat production and conservation techniques the room temperature aimed at is  $65^{\circ}\text{F}$  - only  $5^{\circ}\text{F}$  above the critical  $60^{\circ}\text{F}$ .

The body temperatures of animals are as follows:- cattle,  $100.9^{\circ}\text{F}$ ; sheep,  $102.3^{\circ}\text{F}$ ; horses,  $100^{\circ}\text{F}$ ; pigs,  $102.5^{\circ}\text{F}$  and goats,  $102.3^{\circ}\text{F}$ .

It is generally true that under modern farming standards cow-sheds, horses' stables and pig-sties are large well-lit structures. McLean of the Hannah (Dairy) Research Institute conducted experiments into the heat production of, and therefore energy requirements of, and growth of, calves, two weeks to five months old, in different 'houses'. 'We found', he wrote, 'that even in the best insulated house the temperature increase due to the animals' presence averaged no more than  $7^{\circ}\text{F}$ ; in the open house ( a three sided single brick shed) it was usually less than  $1.8^{\circ}\text{F}$ . This of course is scarcely enough to counteract outside temperatures even under modern animal housing conditions.' (12)

He went on to observe that, 'pigs, being smaller animals than cows and calves, produce a lot less heat and are usually kept in small houses which consequently have a

higher ratio of wall and roof surface (for losing heat) per weight of animals. Houses for young pigs are often heated in contrast to calf houses because pigs are far less tolerant of cold.' It is a reasonable assumption that earth floors would have been even less likely to have conserved heat. Thus it seems improbable that even in a pig-sty or cattle shed, the required temperature would have been reached. Besides, the cattle were often kept outside in the summer.

#### Temperature recordings in Roxburghshire 1976

Recently temperatures have been recorded for several days both inside and outside a small cow byre in which there was a cow. The month was December, and the figures obtained are recorded below.

<u>Inside byre</u>		<u>Outside byre</u>	
<u>Max.</u>	<u>Min.</u>	<u>Max.</u>	<u>Min.</u>
41	39	39	26
45	37	34	21
41	37	35	23
41	37	37	35
45	39	39	32

It appears even in this small series that there are two pointers towards what one might have supposed would be found.

If there is a source of heat such as an animal which has virtually a fixed body temperature, this animal must produce more by catabolism the colder is the ambient temperature. If it were not so then the animal would tend to have its body temperature falling, and per contra rising, to unacceptable levels depending upon the surrounding

temperatures. It is completely improbable that this ambient shade temperature in Scotland will ever be higher than that of the animal. Therefore the heat exchange is always going to be outwards from the beast, and thus the tendency is to warm the surrounding air. The colder that is, the greater heat production there will be in the beast, and relatively the more heat will be lost to the air. This is probably a greater factor in pigs rather than any other domestic animal; all the others having a hair coat which helps to prevent heat loss. So, the lower the surrounding air temperature the higher the level in terms of degree difference should one expect the temperatures inside and outside a 'stall' to be. This is borne out by the figures above. If this is true, then in the warmer times of year it would be observed that the ambient temperatures in a byre are extremely unlikely to have been raised a necessary  $5^{\circ}\text{F}$  or more to give the critical  $60^{\circ}\text{F}$ . That it is of the order of  $5^{\circ}\text{F}$  at least is implicit in the following figures for Perth over the years 1911 to 1947.

(13) The mean daily temperatures for June, July and August were  $56.2^{\circ}\text{F}$ ,  $59.5^{\circ}\text{F}$  and  $58.2^{\circ}\text{F}$ . The average daily range of temperatures in these months was  $18.3^{\circ}\text{F}$ ,  $16.9^{\circ}\text{F}$  and  $15.8^{\circ}\text{F}$ . This implies that during the coldest time of day, after sundown and before sunrise, the temperature fell in June on average to  $47.1^{\circ}\text{F}$ , in July to  $51.1^{\circ}\text{F}$  and in August to  $50.3^{\circ}\text{F}$ . In fact the recorded minima over these years were - June,  $31^{\circ}\text{F}$ ; July,  $35^{\circ}\text{F}$  and August,  $31^{\circ}\text{F}$ . In these cases the animals in their stalls would have had to raise the ambient temperatures by nearly  $10^{\circ}\text{F}$ . This is



virtually impossible within the quoted range.

The Hannah Institute findings implied also that the most critical factor in this sum was the nature of the 'stall'. If there was a perfectly insulated stall the temperature would rise until the animal died of hyperpyrexia. The modern figures indicate that even with modern sties the temperature would not be raised sufficiently for the purpose in hand. Two hundred years ago the sties would have been less well insulated. The colder surrounding air was for ever moving and being re-cooled, and the critical temperature would have been reached seldom except on very hot nights. It is not apparent that these occur more often than seven times a year at most.

This temperature factor is not one which is to make a building more attractive for a resting mosquito, but one in which the temperature is sufficient for the plasmodial cycle to take place. There may well be mosquitoes, and perchance a human carrier of plasmodia, but if the temperature is not sufficiently high for the intra-anophelene cycle to take place, malaria will not be transmitted.

### Summary

The significance of the usually recorded mean temperature is discussed and shown to be inappropriate for the development of plasmodia.

Temperature records show that the number of occasions

on which the critical temperature of  $60^{\circ}\text{F}$  is reached and remains at that level for the hours of the night, when mosquitoes feed, is very small in Scotland. This temperature of  $60^{\circ}\text{F}$  is critical, not for the breeding of mosquitoes, but for the intra-anophelene plasmodial cycle.

It is not apparent that the mean monthly summer temperatures have altered significantly in the last 200 years.

The ability of in-dwelling animals to raise the ambient temperatures in their stalls to the critical level is discussed. It is improbable that they would have been able to achieve this temperature in the mosquito roosts in Scotland in the eighteenth century.

The influence of the sea on the coastal area temperatures is noted; also the apparent effect of large land masses.

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## CHAPTER 8

Malaria - the carriers.

The carriers. Returning soldiers, sailors or merchant seamen and other civilian travellers. Also immigrants or farm labourers who had been working in England.

### The necessity of having carriers

Plasmodia may continue to exist in the human body after an acute episode of malaria has finished. Indeed relapses may occur for at least two years. After that length of time the numbers of plasmodia in the peripheral blood stream are small and it is a probability that the dose of parasites absorbed by a feeding mosquito would be insufficient to promote an acute manifestation in another human being after injection by the vector. Thus if malaria was 'the scourge of Scotland' it is almost essential that there should have been a steady influx of carriers from outside the district. It is believed that children infected with plasmodia are often the source of parasites in a community. In the eighteenth century in Scotland the child mortality was very high, no doubt promoted by such diseases as dysentery, diphtheria and probably tuberculosis, as well as smallpox, typhus and cholera. Thus chronic malaria carriers might not have survived until adulthood. Furthermore it has been

noticed that children who are chronic malaria carriers have a higher rate of splenomegaly than others. This splenomegaly is very apparent although it occurs less commonly the further north one lives. (14) No hospital records, and only one clinical record, have been found suggesting this condition in Scotland.

It is highly probable that malaria existed in parts of England during the period under review, just as it was proved to exist in those same places a century later. It was reported in Scotland that virtually a whole village would have expected to suffer from ague annually, as in Barrie and in St Vigean, a parish of 1,369 souls, where the minister 'had often seen in the months of March, April, May and autumn 15-25 people down with the disease'. (1) If this is so, almost it must be the case that there was more than one initial carrier. It is improbable that St Vigean, a small agricultural parish next to Arbroath, without a seaport of its own, should have had two or three inhabitants who were, if not annually, at least regularly, infected with malaria in some 'foreign' district. Of the inhabitants of such a locality in the first half of the eighteenth century, the number of those who travelled to a place where they were likely to have contracted malaria was probably extremely small.

#### Improbability of effective therapy

Also in the times of which this is written the probability of quinine being used by the labouring classes

was very slight. Thus if an inhabitant of St Vigeans was infected with malaria he would have become a chronic carrier for he would not have taken sufficient, if any, plasmodicide. The richer classes who travelled to foreign parts might have been able to buy quinine but no record of this has been found in travellers' diaries nor in their travelling medicine chests. (2) However clinical records do exist of treatments with 'bark' recommended by doctors. So, of all the potential travellers to malarial areas, many were unlikely to have had the disease cured before their home-coming. However, this remains a possibility.

The Statistical Account broadly hints that ague was a disease found only in the labouring classes. If that is so, because of the housing conditions, it is most probable that it would be transmitted within that class of living standard. Therefore the problem is that of the introduction of the disease into the parish community.

#### The probable travellers

The immediately obvious localities where potential carriers could have been infected with malaria were the English Fens, Essex, or one of the nearby European countries where it was indigenous. Possibly also these should include tropical or semi-tropical lands. In the eighteenth century the inhabitants of St Vigeans and Abernyste would only have gone to far away malarial areas whilst serving in the army, the navy or the merchant navy, or as temporarily emigrant labourers. If Scotsmen



had joined the army probably they would have joined a Scots regiment. If this regiment had served abroad, and the soldier had returned thereafter to his native village, possibly he could have brought malaria with him.

### Eighteenth century Scots battalions

During the eighteenth century the British infantry of the line consisted of 70 or 80 regiments. Of these, five were Lowland Scots, and only one, the Black Watch, was a Highland one.

The 'Royal Scots' battalion consisted of 227 Scots, 57 Irish and 4 English in 1767. By 1788 it consisted of 231 Scots, 105 English and 53 Irish. Battalion strength was thus of the order of 300 - 400 persons. There were only six Scots battalions until 1757 when a seventh was raised, as the 2nd Black Watch. Three more were raised after 1770. So that there were about 1,500 Scots men in Scots battalions until the end of the century when the numbers rose to around 2,500. At that period ague disappeared.

### Illness whilst serving

If a serving soldier became ill he remained with his regiment until he recovered; or, if he became permanently unfit, until he was discharged from the services at whatever place his regiment was then serving. No such thing as home leave existed.

### Regimental home service

Out of all the Scottish regimental battalions only the following returned to Scotland from what has proved to have been a malarious area, i.e. the Netherlands, south-east England or the West Indies. Indeed the last may be largely discounted as the incidence of vivax malaria there is not so high as other types of malaria, all of which have a higher death rate.

The 2nd Royal Scots went from the Netherlands to Inverness and Fort William in 1745 until 1748. The Royal Scots Fusiliers 'marched' to Scotland from Holland in 1715 and remained until 1727. In 1746, for a year, the Kings Own Scottish Borderers served in Scotland, having been in Holland. They served again in 1764-1768 after two years in England. None of the other Scots battalions could have acted as carriers.

### Soldiers returning after 1917

The problem was much greater in later years. In 1917-1920 large numbers of British soldiers had been to malarious areas and had contracted malaria. There were half a million cases in British and Dominion troops! During the years mentioned 34,000 soldiers with malaria had returned to the United Kingdom from the various fronts, and five camps were set up in the south of England for their follow-up treatment. By 1921 in the vicinity of the camps, 500 'civilian' cases of malaria had been notified mostly in Kent, Essex and Hampshire, but some of them as far north as Norfolk. (3) It is thus



possible that malaria might have become indigenous in Scotland if conditions had been suitable. This would have been an even greater possibility inasmuch as quinine, the only available plasmodicide, is now known not to be effective invariably. Malaria did not become indigenous.

#### Review of diseases in the army

Pringle wrote in 1764 and gave an account of various campaigns in the Low Countries. He did so also for the campaign in North Britain in 1745-46. (4)

#### Campaign in 1746

Despite the fact that 6,000 Dutch troops and several British battalions were brought over to Scotland in 1746, Pringle reported that, 'During the whole of the expedition this body did not lose above 40 men, though there had been in all between 600 and 700 ill'. In the beginning of March the troops moved from Perth to Aberdeen via Montrose leaving 300 sick behind. 'The weather being sharp with snow, the inflammatory diseases continued.'

Apart from the battle casualties at Culloden, no other illness was reported, until the troops were established in Inverness. Prior to this Pringle reports that 'there had been much measles and smallpox in the town, and there was the usual jail-fever amongst the prisoners.' But a reinforcement of 'Houghton's regiment from Holland reintroduced the malignant fever' and there were 200 cases in the first few days after landing. The



regiment was sent to Fort Augustus which 'has always been a healthy garrison, but Fort William has ever been sickly and in particular subject to agues and the bloody flux'. The Statistical Account makes no mention of agues and intermitting fevers in that parish.

So although the countryside was fought over and marched through and billeted by the troops which had come from the malarious areas of the Low Countries, there is no report of the troops acting as carriers of ague.

#### Ague in soldiers returning in 1816

This apparent failure to convey to the civilian population that which might have been malaria is reinforced by a similar report in 1816. In this year the 78th regiment had recently arrived in Scotland from Belgium where it had been employed. The second battalion had the reputation of being the unhealthiest formation in the army. (6) They had so many soldiers ill, there were 100 specifically with ague, that the battalion had to be taken out of the order of battle for Waterloo. They returned to Britain, landed at Ramsgate and marched by way of Canterbury to Aberdeen. The record shows that on their way there authority was continually paying off and discharging those who were ill. Having reached Aberdeen the battalion was dispersed to Fort Augustus, Fort William and Fort George.

#### Ague in soldiers not transmitted to civilian population

In that year the number of soldiers suffering from

ague and intermitting fever in Scotland was swollen to 179 by the arrival of this regiment. In the following years the numbers with intermittent fever are given. In 1817 - 20 cases; in 1818 - 2 cases; in 1819 - 9 cases; in 1820 - 27 cases; in 1821 - 2 cases and in 1822 - 5 cases. (5)

#### The discharged invalid soldiers

It is reasonable to suppose therefore that most of these 'extra' cases were from this regiment in the year 1816. Many of the victims may have come from Scotland. There were only 20 cases in Scotland the following year in the army. Thus the majority were cured, which is improbable given the available drugs. Alternatively those who were ill obtained their discharge and returned, probably as carriers to their civilian homes when they could. If it had been malaria, and that is very probable having been camped in a malarious area in Belgium, then there would have been relapses of the disease and many of these would have occurred as spring intermittents the following year.

The army records do not confirm this. Furthermore there is no record of any spread of the disease to the local population such as occurred in 1921 around Epsom!

Thus these probable carriers apparently did not act as sources of infection for new civilian cases in Scotland, nor apparently did the forces from Holland 70 years previously. There is therefore a presumptive

difference in the situations between Scotland and England.

### Possible differences

In Scotland it is possible though improbable that there were more animal hosts than in England. At least in the mid-eighteenth century the civil war conditions probably removed many cattle from being potential hosts.

Thus the zoophilism of anophelene mosquitoes might have been altered in favour of anthropophagous tendencies with resultant spread of malaria. This did not occur.

Records claim that ague in Scotland died out as a result of land drainage which is presumed to have preceded a dearth of mosquito vectors. Accounts appear to show that although drainage was undertaken much land remained undrained and much reverted to its previous state. There are still anophelene mosquitoes.

However thermal conditions with a precise minimum temperature are essential for the spread of malaria and it is believed that these conditions were not met in Scotland during the eighteenth century. Then housing was inadequate and even the proximity of animals may have failed to augment the external temperatures to the necessary degree. The imported diseases of 1746 and 1816 not only were dramatically reduced in numbers but did not spread to the civilian population.

### Royal Navy

Sinclair, referring to the families of farm labourers



wrote, 'The navy derives little or no advantage from this source'. (7) It is more probable that recruits for the navy came from the towns and small harbour areas on the coast rather than from the inland farming areas.

The length of time during which a sailor was away from home was to be numbered in years and not months. Furthermore it is the case that the navy served abroad in stations where the malaria was mainly due to *P.malariae* or *P.falciparum*. It is in the highest degree improbable that these plasmodia are transmissible under natural conditions in Great Britain.

Blane wrote, 'Observations on the diseases incident to seamen'. (8) The worst problems were the fevers. They used Peruvian Bark whenever they could get it. He also wrote of 'a better brand named 'Red Peruvian Bark' brought firstly to England in a Spanish Prize in the year 1781'. This implies that 'bark' had been used before 1781 in the navy.

It is not mentioned anywhere that sailors were given home leave after their illnesses. Supposing it was so, however, they might have been as likely to have imported malaria at the end of the century as 40 or 50 years before. However they probably did not have vivax malaria. Furthermore modern ideas do not agree that bark would have cured their diseases.

### Merchant Navy

Not only the Royal Navy but also the Merchant Navy lay in their ships in the Thames estuary. The latter went abroad to malarious areas such as Portugal, Spain, the Netherlands and the Baltic and called into the home ports up and down the east coast.

Indeed if malaria was brought home by merchant seamen it might have been introduced through the port of Leith or Borrowstouness. At both places there was a very large foreign and coastal trade. (9) (10) (11) (12) Furthermore the trade continued to increase when ague was dying out in Scotland about 1784.

### Land communication

By 1783 there were 60 stage coaches per month between Edinburgh and London. Malaria had not died out in the south by that time and yet there is no record of its re-introduction into Scotland as a consequence of this traffic.

### Farm labourers' movements

It has been noted already that the minister of the parish of Kirkbean, writing for the Statistical Account, said that the source of ague had been those labourers who had gone down to England for the harvest season. However with the improving agriculture at home this annual exodus was no longer a feature of the life in that parish.

(13)

If 'malaria' had become indigenous it is a matter

for speculation why it had died out by the end of the century. In those days it would not have been on account of effective treatment and probably not for lack of mosquitoes. Certainly it was not, as the minister suggested, as a result of inoculation. Perhaps 'malaria' never was indigenous - although returning farm labourers may have brought it with them - for conditions were perhaps unsuitable for its spread.

On the other hand, it may have died out because no new cases were imported. This does not comply with the repatriation of the soldiers in 1816.

#### Endemic malaria and splenomegaly in children

It is well recognised that in a community in which malaria is endemic, the children are probably the most fruitful source of infection for others. Children are easy targets for hungry mosquitoes. Children become splenomegalic chronic carriers so readily that this particular feature is both well known and easily observed. It was not noted in the ague districts of Scotland. This may be because the children had died of other diseases before they had attained the carrier status. It may also be because the clinical records are imprecise.

Hackett and Missiroli observed that the incidence of splenomegaly becomes insignificant the farther north the disease is found. (14) This may be the reason for the lack of notes on the 'ague-cake' of young Scots children. So, in such communities as Kirkbean or St Vigeans or



Abernyte there may have been either many chronically infected children, or it would have been necessary to have had a regular annual source of infection from outside the district. The arguments against this have already been made. Nor was the ague carried from the affected parishes to the northern counties. Equally Donaldson specifically noted about Angus that the lands were drained - 'Highland labourers came to work in the late summer and autumn'. 'This district is closely inhabited and the great body of the people are employed in husbandry. ... A considerable number of strangers come here every spring from Inverness-shire and other northern counties each of whom returns to his home county about Martinmas with eight or ten pounds in his pocket.' (15) There is no mention of these labourers becoming ill at their work; and more particularly no mention of them becoming a source of ague in their home districts.

#### Further records of carriers

Occasionally there are records of carriers of ague in the civilian population. Monro recorded the case of a man who 'brought a quartan ague and the French pox from England. The ague was in vain attempted to be cured by the common remedies and in the meantime the pox advanced. ... After taking four doses of sweet mercury he had a severe fit of the ague but after it was over the mercury was repeated. He never had more appearances of ague. I was willing to borrow this case because so far as it relates to the ague it was an unexpected uncommon cure of

a disease little known in this country ... the quartan agues not having been seen here until within the last ten years (1770) in which they have been observed in some parts of the country but have not been general.' (16)

It is the present belief that quartan malaria is not endemic in England, and could not have been. Secondly, as the physician remarked, 'sweet mercury' would have been an unexpected and uncommon cure for any form of malaria.

It was written of the Jedburgh district towards the end of the eighteenth century how, 'Not fewer than eight estates have recently been bought by those with fortunes from the East Indies'. (17) In those days the chances of an East Indian resident staying long enough to make a fortune and not having some form of malaria must have been very remote. Thus someone would have carried malaria home. There are no records of ague in the Jedburgh district!

Another doctor wrote of two patients whom he had seen with ague. One had lived in England, in Hampshire for three years, but had never suffered from intermittent fever. The other had lived in America where he had had the ague but not for the last four years. (18)

### Summary

All manner of possible carriers are reviewed. The army might readily have brought malaria from the Netherlands in the eighteenth century. When there is an

official record of them bringing ague to Scotland in 1816 there is no record whatsoever of any recurrence of that disease in Scotland. It is more probable that the army brought typhus from the Netherlands in 1746 and not malaria. Neither the Royal Navy nor the Merchant Navy are likely to have been the carriers of the eighteenth century ague. There is no possible reason for supposing the latter were less likely to have acted as carriers in the nineteenth century. Nevertheless ague died out. The same argument applies to any farm labourers temporarily emigrant to East Anglia.

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## CHAPTER 9

Treatment of agues. Modern description of malaria.  
Seventeenth, eighteenth and nineteenth century descriptions of agues.

### The discovery of plasmodial parasites

It was impossible to make a diagnosis of malaria as that is now recognised until Laveran had discovered the plasmodial parasites in the human blood in 1880. Before that time agues and intermitting fevers were described and diagnosed, but there was no precision in those diagnoses.

### Treatment with bark

Sydenham and his contemporaries found that some cases of such fevers responded to the exhibition of cinchona bark. However all those who recovered after being given cinchona had not necessarily had malaria. Indeed from the very diversity of substances which were recorded as being 'cures' for ague, it cannot have been the case that all those diseases which had thus been 'cured' could have been malaria. They might have been any acute fever which ran a self-limiting course, but appeared to be cured by the exhibition of the named substance.

Certainly the most important of these was 'bark' in one of its forms. After its discovery and when it had been

brought to Great Britain it achieved a reputation for curing all manner of illnesses. (1) Indeed it is now recognised that it does not 'cure' malaria. Because of the widespread demand for it, it was scarce and not always pure. (2) Its refinement was expensive (3) and in Scotland it did not appear in a Scots Pharmacopeia until 1792. (4) (26) However its exhibition is recorded in manuscript clinical case notes many years before this. It is not mentioned in any of the travellers' diaries of the period; nor is it found in their medicine chests. (5) (6) (25) Thus it is improbable that any of the farm labourers who suffered from ague would have been able to find, let alone buy any of this drug. Fowler's solution was frequently recommended, and almost invariably phlebotomy and a purge. (8) (9) There were many other remedies suggested. None contained any drug which would have cured malaria. Similarly Peruvian bark was prescribed for many diseases other than ague - for example it was prescribed for epilepsy. (7) (27) (28)

Although all cases of malaria are agues, the reverse is not true. Although many illnesses were treated with bark and the patient recovered, he had not necessarily had malaria.

#### Vivax malaria symptoms

From the time of Hippocrates it has been recognised that in an attack of what is now called vivax malaria, there is a feeling of extreme coldness, followed by an uncontrollable shivering fit, during which the temperature



of the body rises in striking contrast to the previous coldness, the whole 'fit' terminating in a drenching sweat. Then, sooner or later, the series of events recurs.

### First attack

A person's first attack of malaria is often preceded by some non-specific symptoms. These may be a mildly sore throat and a dry cough; or perhaps some abdominal discomfort, and very frequently muscular pains and a headache. After one or two days the typical cold fits, hot fits and sweating start, although the particular tertian course may not develop until after the first three or four paroxysms. Second and subsequent attacks often start immediately with the feeling of coldness. This stage is characterised by the rigor in which the teeth chatter and the limbs shake uncontrollably. This muscular action raises the body temperature which after about two hours reaches, perhaps,  $106^{\circ}\text{F}$  though usually lower than that.

With the onset of the high fever the skin becomes burning hot and reddened, the pulse rate rises consonantly with the degree of fever and the bedclothes are discarded in an attempt to become cool. In the course of the eight to ten hours for which this stage lasts, delirium may develop. The hot stage is succeeded by a period of drenching sweating during which the aches and pains grow less and disappear; the temperature and the pulse rate fall, and at the end of it the patient feels remarkably well; not only by contrast with what he has just been

suffering.

With succeeding paroxysms, which classically occur every other day, there is a rapid onset of anaemia, possibly some jaundice and an enlargement of the spleen and occasionally of the liver. Also there is almost always the appearance of herpes labialis. The combination of all the foregoing and the herpes is thought by some to be diagnostic of malaria. The characteristic enlargement of the spleen occurs earlier and more frequently in vivax malaria than in the other forms and it is particularly obvious in children.

### Immunity

Kitchen, writing about the disease, says 'The prodromal period has symptoms exactly like those of the start of influenza but usually more marked in those who are more susceptible to the plasmodium'. (10)

There is some immunity to the parasite and Jones wrote, 'The B.Lymphocytes at any rate in falciparum malaria begin to produce IgM and IgG antibodies directed against the merozoites; and excess antibodies are seen in the plasma in the next few days ... These antibodies have in fact been transferred from infected hosts and found to be protective, and the protection was 'host specific'. The role of antibody has been shown by the transfer of immunity from mother to foetus with the protection of the neonate whilst the maternal IgG persists. It has not been clearly shown whether decreases in immuno-globulin levels contribute to the relapse of malaria.' (11)

The usual course of an untreated case is to have up to 20 paroxysms after which these become less and then die out. Thus an untreated case may last for three to four weeks.

#### Degree of infestation

However there are variations. If someone is infected for the first time in the autumn, it will be possible to find gametocytes in his peripheral blood after about seven days, and he will have the start of the typical syndrome in 10-14 days. Mosquitoes may harbour many hundreds of oocysts and may retain their ability to transmit the disease for at least a month after becoming infective. However patients who have been bitten a month or more after the oocysts have ruptured seldom develop the full syndrome within the usual incubation period. Often this does not appear until about 28 weeks thereafter .. the 'spring intermittents'. This may be due to some immunity in a person who has had previous attacks, but also it may be due to the fact that a later victim of the mosquito may have only a few parasites injected when he is bitten. This idea is supported by the finding that five or six mosquitoes from the same laboratory batch, after feeding on the same subject only produced the syndrome after 27 weeks. But when the salivary glands of 50 mosquitoes from the same batch were injected intravenously, the syndrome developed in about 15, the usual number of days.

(12) It is possible that this anomaly is due to the age of the parasites, for relapses from an untreated case of malaria may occur months or even years later and are



invariably milder than the original attack.

### Liability to infection

It has been observed that some people appear to be more attractive than others to the bites of mosquitoes. Amongst other factors may be the one of thermotropism. Howlett observed that those in an attack of fever were more liable to be bitten than those who were not. (13) So that if the paroxysm occurs in the early afternoon, and characteristically it does, it will not have subsided before the mosquitoes emerge at dusk for their evening meal.

### Relapses

Patients with latent infections, that is to say those who have not had effective treatment, can, and usually do, suffer a relapse. Those who do have such a relapse usually run to a spontaneous recovery and cease abruptly to be infectious. Many of the relapsed cases of vivax malaria are induced by, or at least coincide with, the rising temperature of the following spring, or with increasing relative humidity. Such persons serve to carry the infection from one season to another and have it transmitted from them. It is apparent therefore that in patients who are exposed to attacks by anophelenes the more prevalent are the acute untreated cases of malaria the higher will be the rate of infection of the mosquitoes.

'Such acute attacks may be observed in persons at all ages in areas of low endemic levels. The higher the endemic level rises however, the more acute attacks will be

restricted to young children and infants, until, at the highest levels, individuals in these restricted age groups become of the greatest importance as sources of infection.' (14)

That comment by James was written of the Far East and not of Great Britain, where nevertheless it may have been applicable. According to Swellengrebel it was applicable to Holland. (15)

### Spring intermittents

'Spring intermittents' appear to be a feature of malaria in northern Europe. It has been argued that such attacks are due to the small numbers of parasites injected by a feeding mosquito in an European autumn. Also they may be due to the length of time the parasites have been harboured in the vector. They might be due to the almost haphazard survival of some sporozoites in over-wintering mosquitoes, which feed on and infect new material in spring. However only a very small percentage of vectors remain infected. Lastly it has been suggested that the partial immunity of the victim may be a factor. All this agrees with Swellengrebel's theory which categorically stated that only *A. m. atroparvus* could possibly transmit *P. vivax* in the New Year. Furthermore, because of the paucity of surviving sporozoites, that in itself was extremely unlikely. So, if the Scottish 'spring intermittents' were malaria, it seems that the only explanation for them could be that a partial immunity plays its part with a series of minimal infections in autumn.

### Duration of rigors

It is assumed by Kitchen that the great majority of the parasites are separated into two pyrogenic broods whose sporulation times are separated by 24 hours. Gradually one brood supercedes the other. He also noted that 'the rigor lasted a mean 55 minutes in 713 observed cases, and that over 90% of the 'paroxysms', which lasted 8 hours 38 minutes, started in the afternoon and two-thirds of them between 3.00 p.m. and 8.00 p.m.'.

### Splenomegaly

'By the end of the second paroxysm the spleen is usually enlarged to the costal margin and thereafter enlarges to size two and occasionally size three.' (10) In first attacks it is soft and may be tender; indeed many patients complain of splenic area pain. Once the infection is brought under control the spleno-megaly rapidly declines, but immediately there is a relapse, or a new infection, it enlarges again and eventually becomes the hard 'ague-cake'. James alleges that splenomegaly is of greater value to the epidemiologist as an indication of the prevalence of malaria, than it is as a diagnostic aid to the physician. (16) Spicer says that in a hypoendemic area a splenomegaly rate of 15% is indicative of malaria in the area. (17) It is certain that in an endemic area a chronic enlargement of the spleen will be more obvious in children than it is in adults.

However the idea has already been expressed that the farther north one goes the more temperate is the climate



and the less is the incidence of splenomegaly. (18)

### Anaemia

The parasite density in a vivax infection is of the order of 10,000 - 20,000/cu.mm. for two or three weeks. Not only do the parasites destroy the red cells, but of course alongside their destruction goes the probable enlargement of the liver, and the almost certainly mild icterus.

After three or four weeks illness the red cell count may be reduced to 1.5 million/cu.mm. and the haemoglobin may be reduced to three or four G%. These deficits can be made up in a very few weeks in the absence of any counteractive factors. Kitchen goes on to say, 'Our own experience indicates that the loss caused by a parasitaemia upwards of 5,000/cu.mm. can easily be replaced by a patient. In the face of such evidence that attribution of anaemic states to hypothetical malaria infections, or of malarial infections in which a few plasmodia can be demonstrated irregularly, is obviously unacceptable.' (10)

In the eighteenth century in Scotland it is probable that the diets of labourers and their families did not have a high iron content. It is very improbable that they would have been given iron supplements. Thus if their illness had been malaria they might have continued unfit to undergo the rigors of eighteenth century life.

### Uncommon clinical manifestations

In those places where malaria is, or until recently

was common, it can of course be observed how variant are the syndromes which constitute malaria. Most and Hayman wrote an account of some uncommon clinical manifestations of vivax malaria. (19) 'In a small number of patients the nausea and vomiting may precede the paroxysm by a day or two and be mistaken for acute cholecystitis, appendicitis or intestinal obstruction. Chronic cases, i.e. relapses may simulate Banti's syndrome for which one of our patients had a splenectomy ... Other simulated diseases in order of frequency were acute tonsillitis, cellulitis, thrombo-phlebitis, pyelitis and pneumonia.' And with emphasis on the central nervous system, 'meningitis is a possibility even in Vivax Malaria; and epilepsy. The most common confusing findings may be severe nausea, vomiting, abdominal pain and tenderness, diarrhoea, fever, slight jaundice and anaemia and spleno- and hepato-megaly.'

#### Earlier clinical descriptions of ague and intermittent fever

Agues and intermittent fevers have been declared to be synonymous with malaria. Over the last 300 years medically qualified people have written accounts of these illnesses. It is obvious that they considered agues and intermitting fevers to include diseases other than malaria. Sydenham wrote, 'Of the epidemics of intermittents that show themselves in spring they begin as soon as January and reach their height about the 24th of March ... To this class belong measles so do the spring tertians ... No one that I know had ever died of one.'

'In the year 1661 the autumnal intermittents ... broke out afresh about the beginning of July ... In many places the mortality was excessive and whole families fell victims. The tongue of the patient blacker and drier. The apyrectic intervals were less defined ... The symptoms were more formidable and the disease in general was deadly beyond the degree of an intermittent.'

Later he continued, 'All agues begin with shiverings and rigors succeeded by heat and terminated by sweats... When the sweats have broken out copiously the fit seems to have gone off and he that was just sick has become a healthy man. Sooner or later however the paroxysm repeats its attack.' (8)

Elliotson, writing about intermittent fevers said 'Sometimes the term is applied especially in the plural number to all febrile diseases including primary eruptive and acute local inflammatory fevers ... The ague, the simplest and commonest of these diseases is not uncommon in the cold weather of our spring months... There are occasionally incidental symptoms such as tetanus, convulsions, fainting, violent delirium and the appearance of petechiae on the skin.' The paroxysms were usually over in 18 hours. However, also 'he saw a paroxysm which lasted only one minute. How the stages were divided I do not know!' (20)

He also recorded, 'There was one case in which the vertical half of the body suffered an ague. During the



cold fit the other half becomes convulsed ... The duration of ague is various. It may be ephemeral consisting of one paroxysm or it may last for many years, at least it did so before we could cure it so effectually as we now can do.' (1846)

Elliotson made this particular observation that Edinburgh with its North Loch was a great source of ague until it was drained. 'When I say ague, I mean fever of an aguish character whether remittent or intermittent and many diseases of this description are unquestionably mistaken everyday for real typhus.' (21)

Elliotson quotes Bancroft, 'Malaria is the constant scourge of the earth. Not the occasional, but the constant scourge. It produces not only fevers, but very frequently dysentery, cholera and sometimes neuralgia, and it causes a remittent or intermittent character to be given to other diseases.' And to prolong the uncertainty of the meaning of the terms he goes on to report how 'in years 1667-1692 two thousand people died in London, of dysentery arising no doubt from the same cause as ague.' (22)

McCormac writing in 1842 said, 'A great variety of intermittents probably fifty or more have been described ... England, apart from Essex and parts of Lincolnshire, can hardly be regarded as a malarious region and Ireland not at all so.' He went on to observe that northern districts were not subject to agues because the thermometers did not rise to a sufficient height. 'If the

temperatures were ten or twenty degrees higher the areas would become dens of pestilence.' (23)

#### Clinical records of the eighteenth century

In the eighteenth century Hope wrote clinical notes on his patients. One small packet of letters referred to 'agues', and these might have been malarial infections. (24) 'David Anderson age 15 had aguish paroxysms every day in early April. However his cold fit lasted only ten minutes and the hot one was of somewhat longer duration.' 'John Angier age 23 was having regular attacks of tertian which supervenes at 11 a.m. The coldness and rigor last until 1,0 p.m. and the hot stage for two hours. One and a half years ago he had ague for twelve months during which time he lived in London. He was seen on April 19th and the Jalap pills which had been prescribed cured him by April 26th. James Coxwell's cold stage rarely lasted half hour; the hot stage took the same time and the sweating went on for 3 hours. Two days later the cold stage lasted  $\frac{1}{4}$  hour. He was given Peruvian Bark on the following two days and was cured two days thereafter on April 24th. William Barrington age 24 was seen on April 30th. Every second morning he has a cold fit; shiver and hot fit, the whole paroxysm seldom lasting less than 24 hours. He also complained of severe pain under his left ribs. This ague had first come on in America four year previously, but hardly ever since. He was taking Bark and was soon cured.'

This truly sounds like malaria, and is the only

clinical note of probable spleen involvement which has been found.

'Duncan Currie was having irregular tertians. He was in Hampshire three years ago but never had intermittent fever. He found that Peruvian Bark had not cured him.' He too was given Pulv. Jalap.Co. and was discharged cured in four days.

### Summary

Malaria is ague - an acute intermitting fever. The reverse is not necessarily true. Malaria properly cannot be diagnosed unless the parasites are found in the human blood-stream. A first attack and a subsequent attack of malaria are described.

The involvement of the spleen and also the commonness of anaemia are noted.

Accounts of agues and intermitting fevers are given by seventeenth, eighteenth and nineteenth century physicians.

Those text book records do not describe always what is now regarded as an attack of malaria. Instead they describe acute fevers of diverse origin. However, some mid-eighteenth century manuscript clinical notes of patients with ague may describe malaria but as the 'cures' are rapid and attributed to Jalap pills, this again throws doubt on the propriety of the synonym.



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## CHAPTER 10

Hospital records - admissions with ague and intermitting fever.

### Hospital records

In the introduction to this thesis it has been noted that a modern author has written that in Edinburgh in the eighteenth century 'whole families were swept away with typhus and malaria'. (1)

Hospital admission records may indicate the incidence of this ague or 'malaria'. Furthermore hospital clinical records may support or deny the notion that 'ague, inter-mittent fever or malaria' as it was variously termed, does seem to be synonymous with the modern concept of malaria.

Such sources of information depend for their reliability on two major factors. The first is whether the admissions to hospital were relatable to the disease rate in the population. It is only 40 or 50 years since there was a general disinclination on the part of an ill person to go into hospital except for some acute surgical emergency. Thus if malaria or ague was a very common disease it might have been the case that few of those ill with it would allow themselves to be treated in hospital.

Secondly the reliability of the information depends upon the diagnosis recorded on admission. It will be shown

that patients were admitted with such apparently unimportant diagnoses that it is implicit that people were not wholly averse to entering hospital. If this is true, then the admission rates for ague and intermitting fevers are indicative of the prevalence of those illnesses. At that point the interpretation of the diagnosis 'ague' arises once more.

Fortunately such records are available firstly for Edinburgh Royal Infirmary (2), and, in contrast, for the Kelso Dispensary (3). The former was situated in a city of 80,000 inhabitants and in addition a garrison of soldiers. Some of these might have introduced disease contracted elsewhere, and might have been admitted to the Infirmary. Therefore these records might reflect the incidence of ague in the population in the city.

The Kelso Dispensary records were made available by a private source. They are now housed in a public collection. This hospital served a large country district in the Borders. The district contained several villages and many farming communities. Nowhere does it come within 15 miles of salt water.

In addition, and by chance, manuscript clinical notes have been found. They record observations on cases of 'ague'. These will be quoted briefly to show the signs, symptoms and course of those illnesses which were diagnosed as ague or intermitting fever. Extensive quotations from these rare reports are to be found in the appendices.

However also it must be observed that it was constantly reported by the writers of the parish records in the Statistical Account that the local inhabitants were very willing to look after their sick neighbours. Thus some diseases spread. This being so, it might be expected that the Kelso admission records would be lower relative to the disease incidence than those of Edinburgh because of the difficulties of communication in the country. Everything written thus far will be reinforced by noting that on 15th April 1781 eight members of a family in Kelso were admitted with scurvy. On the same day six members of an Edinburgh family were admitted to the Royal Infirmary with a diagnosis of 'the Itch'. So it must be apparent that people were readily admitted to hospitals and some at least were willing to go. Thus anyone ill with 'malaria' might have become a patient in either district.

Children are likely to become carriers of malaria. Thus in an area of high endemicity hospital records of children with the disease should be expected. As a general rule children were not admitted to the Royal Infirmary in Edinburgh; whereas this was not the case in Kelso. There are very few records from Kelso of admissions of children with diagnostic labels suggestive of spleno- or hepatomegaly. The only admissions of children who might possibly have had liver or spleen involvement are recorded here. In 1782 a child of seven was admitted with a 'Tumor'. She was discharged 'cured'. In March of the same year a three year old was admitted with jaundice. She



also was cured. In October of the same year a five year old was admitted with jaundice. (3) Those were the only children admitted with anything resembling such complications in a year during which there were 96 persons admitted with ague.

The person who wrote about Kelso in the Statistical Account ten years later made no mention of ague nor intermittent fever in the parish. However in the New Statistical Account written in the 1840's it was stated 'Ague has almost disappeared'. (5) When the 'Old' Statistical Account was written in 1794 it was claimed that ague had virtually died out from the districts where it had been prevalent ten and more years previously. (4) The Kelso Dispensary records show that in 1781 there were 145 admissions for ague and intermittent fever, and in the next six years there was a total of 382 such cases. (3) It is possible that these two claims are reconcilable if it is allowed that agues were not the same disease in the view of the parish recorder, and those who arranged hospital admissions. However in addition a new diagnosis appears in the records in 1782 and influenza is reported. It is tempting to suppose that a new doctor had arrived in Kelso and that he had introduced this more precise diagnosis instead of ague or intermittent fever. The record books are there to prove that no such doctor had been appointed recently. (6)

### Influenza

In Kelso in June 1782 there were seven cases of

influenza, and four in July. The diagnosis does not appear again for three years on either side of that summer outburst. Creighton says that in Edinburgh, 'influenza appeared in the same year, 1782, in mid-May and was at its height in July'. (7) Yet the numbers with 'fever' admitted to the Edinburgh Royal Infirmary then were the lowest three monthly figures for over two years! The admission books show that there were no admissions for influenza in April 1782; one in May; 14 in June and all of these between June 5th and 25th. There were none in July. However it may be surmised that influenza may have been given a different diagnosis. In April 1782 there were five admissions with 'catarrh'; in May one case of 'catarrh' and one of 'pleuritic'; and in June one case of 'pectoral complications'. There were none in July when the epidemic was at its height! If patients with 'itch' were offered and accepted places in hospital it is reasonable to think that in an influenza epidemic several patients would accept the same offer. (2)

All this has been recorded here because in general ague might have been influenza. Also it has been recorded to draw attention to the anomaly of an influenza epidemic in July, and to observe that at the height of the epidemic there were no admissions under that diagnosis in Edinburgh and fewer in Kelso than there had been in June. Nor can it be argued that patients with influenza were admitted with the diagnosis 'fever', for those numbers were the lowest of the year in that July in Edinburgh and lower than average in Kelso. Creighton does remark that the

epidemic was so bad that it had interfered with harvesting. So it is possible that the waning admission figures at Kelso do not reflect the waning of the disease, but the necessity of gathering the harvest. However even in modern times July is very early to contemplate harvesting in that district.

### Non-specific fevers

The precise interpretation for the terms ague and intermittent fever can only be surmised. However in order to produce as little bias as possible, the figures for 'fever' as well as the other two have been abstracted from the records of the two hospitals. It is not known what 'fever' was, but often the terms 'typhus', 'fever with eruptions', 'measles', 'phthisis' and 'erysipelas' are used. When these diagnoses are made those patients with such complaints have not been counted as having 'fever'.

The records for the years 1770-1784 have been given for Edinburgh so that it may not be argued that, the figures for 'ague' being on the wane, they were not comparable with the earliest Kelso records now available, i.e. those of 1778. Table I sets out the Edinburgh figures, and Table II those for Kelso. Table III shows a direct comparison of admissions at Kelso and Edinburgh for those, specifically, with ague or intermittent fever. Thus any bias is removed by quoting ague admissions and intermitting fever admissions. Both names have been written of as 'malaria'. Furthermore, it also removes any



Monthly admissions to Royal Infirmary Edinburgh 1770 - 1784

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1770												
Ague	2	-	-	3	1	4	2	-	1	-	1	-
I.F.	1	-	1	5	10	-	-	-	1	-	-	-
Fever	2	8	7	3	4	8	4	2	5	6	6	6
1771												
Ague	-	-	-	-	-	-	-	-	-	-	-	-
I.F.	-	-	-	4	6	6	2	-	-	-	1	-
Fever	8	3	12	11	21	16	17	9	9	17	23	28
1772												
Ague	-	-	-	-	-	-	-	-	-	-	-	2
I.F.	-	-	-	1	3	-	-	-	-	-	-	2
Fever	24	13	15	14	14	16	11	19	11	15	22	16
1773												
Ague	-	-	-	-	-	-	-	-	-	-	-	-
I.F.	7	1	1	5	3	-	3	5	2	4	-	1
Fever	13	21	25	20	30	21	30	25	34	41	39	24
1774												
Ague	-	-	-	1	-	-	-	-	-	-	-	-
I.F.	3	2	4	3	2	10	-	1	1	3	-	-
Fever	37	48	38	35	24	35	20	26	31	40	25	37
1775												
Ague	1	1	6	2	7	2	-	-	7	3	3	7
I.F.	-	-	-	-	-	-	-	-	-	-	-	-
Fever	25	15	19	21	22	12	9	13	23	21	37	20
1776												
Ague	7	7	-	3	3	10	4	-	-	-	-	1
I.F.	-	-	7	-	1	-	3	2	3	-	-	-
Fever	30	34	28	36	34	25	22	23	13	11	14	5
1777												
Ague	-	-	-	-	-	-	-	-	-	-	-	-
I.F.	1	2	1	1	1	3	-	-	-	-	-	-
Fever	27	39	41	32	36	26	21	18	21	29	30	11
1778												
Ague	4	5	4	4	5	7	5	2	2	1	4	-
I.F.	-	-	-	-	-	-	-	-	-	-	-	-
Fever	7	7	8	6	10	8	6	3	4	5	8	5
1780												
Ague	-	1	5	15	20	8	2	1	7	6	5	3
I.F.	1	1	-	-	2	5	1	-	1	1	-	-
Fever	10	6	3	8	10	13	11	6	11	11	16	16
1781												
Ague	2	7	9	6	17	-	-	1	5	4	3	2
I.F.	-	-	-	-	-	1	-	-	-	-	-	2
Fever	7	9	20	24	22	18	22	44	35	29	23	20
1782												
Ague	2	2	5	16	11	8	6	3	1	4	-	1
I.F.	1	-	1	-	-	-	-	-	-	-	-	1
Fever	13	22	22	10	11	4	3	8	3	8	10	6
1783												
Ague	4	-	2	7	13	13	11	3	11	8	4	3
I.F.	-	1	1	-	-	-	-	-	-	-	4	1
Fever	10	10	4	14	15	12	21	23	25	14	31	28
1784												
Ague	-	4	11	20	17	8	4	5	2	6	-	4
I.F.	-	3	7	2	7	7	-	-	-	1	6	-
Fever	21	19	28	17	19	15	41	30	13	18	31	33

Monthly admissions to Kelso Dispensary in calendar years 1773 - 1737

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<u>1773</u>												
Ague	-	2	-	2	-	-	-	1	1	3	-	1
I.F.	-	-	-	4	1	-	1	-	-	-	1	-
Fever	1	1	2	3	-	-	-	-	1	1	-	2
<u>1779</u>												
Ague	-	-	3	4	3	2	3	1	3	8	-	1
I.F.	-	-	-	-	-	1	1	-	-	1	-	1
Fever	1	5	-	2	1	3	2	1	1	2	2	7
<u>1730</u>												
Ague	2	1	16	14	8	6	5	1	2	12	2	2
I.F.	-	4	1	1	1	-	-	-	-	-	-	-
Fever	9	6	7	10	6	10	23	16	14	6	1	4
<u>1731</u>												
Ague	6	2	33	37	33	10	8	4	6	1	-	3
I.F.	-	-	-	-	-	1	-	-	-	-	1	-
Fever	13	18	22	10	16	17	10	6	17	1	7	4
<u>1732</u>												
Ague	1	9	15	19	27	10	4	5	5	1	-	-
I.F.	-	-	-	-	-	-	-	-	-	-	-	-
Fever	3	3	12	2	5	16	4	2	4	6	5	1
<u>1733</u>												
Ague	1	4	10	12*	7*	10	7	4	5	3	2	-
I.F.	-	-	-	-*	-*	-	-	1	-	-	-	-
Fever	7	3	2	6*	1*	8	4	16	10	4	1	2
<u>1734</u>												
Ague	-	6	16	18	13	8	4	1	1	1	5	-
I.F.	1	-	-	-	-	-	-	-	-	-	-	-
Fever	2	2	1	1	3	9	9	10	18	6	3	1
<u>1735</u>												
Ague	3	2	5	4	4	8	1	4	2	1	1	-
I.F.	-	-	1	1	-	-	-	-	-	-	-	-
Fever	1	5	2	-	5	2	4	3	4	5	2	2
<u>1736</u>												
Ague	2	3	7	18	14	5	5	2	2	3	1	1
I.F.	-	-	-	-	-	2	-	-	-	1	-	-
Fever	3	1	2	3	2	6	4	3	2	1	10	9
<u>1737</u>												
Ague	2	2	12	6	5	5	6	2	-	2	1	-
I.F.	-	-	-	-	-	-	-	-	-	-	-	-
Fever	2	9	5	-	3	3	6	-	1	1	-	2

NB. There is at least one page missing from the records in April May 1733. It can be calculated from the annual reports that during those months there were an additional 24 cases of ague not shown in the figures above.\*

TABLE III

A direct comparison of the monthly admissions to the Royal Infirmary Edinburgh and Kelso Dispensary in the years 1780-1784 for patients with ague or intermittent fever (I.f.) but excluding those with 'fever'.

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

1780

E.R.I. Ague	-	1	5	13	20	8	2	1	7	6	5	3
Kelso	2	1	16	14	8	6	5	1	2	12	2	2
E.R.I. I.f.	1	1	-	-	2	5	1	-	1	1	-	-
Kelso	-	4	1	1	1	-	-	-	-	-	-	-

1781

E.R.I. Ague	2	7	9	6	17	-	-	1	5	4	3	2
Kelso	6	2	33	37	33	10	8	4	6	1	-	3
E.R.I. I.f.	-	-	-	-	-	1	-	-	-	-	-	2
Kelso	-	-	-	-	-	1	-	-	-	-	1	-

1782

E.R.I. Ague	2	2	5	16	11	8	6	3	1	4	-	1
Kelso	1	9	15	19	27	10	4	5	5	1	-	-
E.R.I. I.f.	1	-	1	-	-	-	-	-	-	-	-	1
Kelso	-	-	-	-	-	-	-	-	-	-	-	1

1783

E.R.I. Ague	4	-	2	7	13	13	11	3	11	8	4	3
Kelso	1	4	10	*24	*19	10	7	4	5	3	2	-
E.R.I. I.f.	-	1	1	-	-	-	-	-	-	-	4	1
Kelso	-	-	-	-	-	-	-	1	-	-	-	-

1784

E.R.I. Ague	-	4	11	20	17	8	4	5	2	6	-	4
Kelso	-	6	16	18	13	8	4	1	1	1	5	-
E.R.I. I.f.	-	3	7	2	7	7	-	-	-	1	6	-
Kelso	1	-	-	-	-	-	-	-	-	-	-	-

\*NB In April and May 1783 the Kelso records are missing but 24 extra ague cases were admitted in those months and have arbitrarily been allotted 12 to each month plus the recorded cases.



bias if figures for 'fever' admissions are omitted even if the specifically named fevers are excluded from the total fever figures. The years chosen are 1780-1784. The 1779 diagnoses were not recorded in Edinburgh, and 1778 is Kelso's first year of records.

#### Hospital admissions: Edinburgh

Looking at these tables one must again reflect upon the imprecise use of words. One might be excused for doubting whether the diagnosis 'ague' meant the same thing throughout the years 1770-1784. Yet it can be observed that patients were admitted to Edinburgh Infirmary suffering from that disorder which had been designated 'the scourge of Scotland' ... 14 cases in 1770 followed by three cases in the next four years. (2)

The disease was alleged to be dying out. However, five years afterwards there were 71 cases followed by another four years with such figures.

The figures for ague and intermitting fever have been added together as both have been termed 'malaria'. Thus it appears that in the period 1770-1784 the figures vary between 32 and 114. This must indicate, if the expression means anything, that the temperatures and humidity had changed. There is no reason to suppose there was an influx of carriers. Soldiers did not contribute to the rise.

### Weather conditions

Only two weather reports in the period are extraordinary. The July mean temperatures for Edinburgh were more than 60°F in the years 1778-1783. In fact 1783 was the hottest summer between 1764 and 1840. In 1779 and 1780 the hot spell lasted through July and August. (8) (9) One cannot say about the former year, for the Royal Infirmary records do not show any diagnoses that year, only the names of those admitted. However 1780 was the first of five years showing a notable increase in the incidence of ague and intermittent fever. If the hot spell was associated with an increased number of mosquitoes or an increased viability of plasmodia, this is not apparent in the numbers of those with ague being admitted to the Royal Infirmary either as acute cases in the autumn of 1780 or as an extra number of 'spring intermittents' in 1781. Indeed it is not unreasonable to consider that the spring intermittents, if they were malaria, should have declined by May. The numbers show that they did not.

The other outstanding weather report was that on 31st January 1776 the cold was so severe that 'the milk froze on milking the cow'. (10) Yet in January and February of that year there were more cases of ague than in any month until June 1778, with the sole exception of June 1776. It is also notable that in Edinburgh, in most years, if the numbers of intermittent fevers increased the numbers of ague waned and vice versa!

### Kelso admissions: ague

The first striking aspect of the Kelso figures is the larger numbers of ague cases, especially having regard to the smaller population at risk. Secondly the highest numbers of admissions were in March, April and May. This supports the Statistical Account report on the Carse of Gowrie. It said that the numbers ill annually with ague occurred during, and disrupted, the sowing times.

### Spring intermittents

Spring intermittents of malaria may arise because the large number of mosquitoes in the previous autumn have favoured an increased number of cases then and a prolongation of the malarial season. As a result, apparently, patients infected late in the season with a small number of parasites may not experience the frank disease until those parasites have reached a sufficient density in the following spring. Indeed in Edinburgh only the records of autumn 1783 and spring 1784 will agree with this theory if ague was malaria.

Only in 1780 could it be said of Kelso that the intermittents of the following spring were preceded by an autumnal rise in ague figures.

Perhaps, therefore, some of the many spring cases of 'ague' should more probably have been influenza, at least the ones occurring in March and April. In that case then perhaps the diagnoses were made incorrectly in May!



### Imprecise diagnoses

Many conclusions may be drawn from this. The best is to believe that modern diagnoses are more precise than they could have been 200 years ago.

The Statistical Account for Edinburgh makes no comments on disease. Throughout the country, however, ague was said to have disappeared by the 1780's. There were 17 cases of ague admitted to the Edinburgh Royal Infirmary from 1770-1774. There were 346 cases of ague admitted in the years 1780-1784. (2) In the latter period there were 448 cases of ague admitted to the Kelso Dispensary. (3)

Someone received an adequate dose of parasites in late summer or early autumn, a period of the year nowadays thought of, with reason, as the malarial season. Such a person would probably have had an acute attack of malaria within 14 days. In the eighteenth century in Scotland it would have been extremely improbable that he would have received enough quinine to 'cure' his illness. Thus the patient would almost certainly have had a relapse. If people with relapses had been admitted to hospital, they of all people would have been diagnosed as having ague or intermitting fever, for relapsed cases almost invariably assume the typical paroxysmal pattern at the beginning of the illness. So the 'spring intermittents' may easily have included not only those autumn infected cases but also relapses. Only the records of autumn 1783 and spring 1784

will agree with this theory. It is quite evidently not true for the years 1770-1771, 1773-1774 or 1777-1778.

#### Comparison of hospital records with recorded history

It is almost beyond the bounds of credibility that the admissions for ague itself in Edinburgh should vary in the way the records proclaim, if ague was malaria.

It is almost beyond the bounds of credibility that when 'ague' was vanishing from, indeed had virtually disappeared from, Edinburgh that the percentage of 'malaria' cases to the total admissions should have risen from 2.75% in 1770 to 6% in 1784.

Indeed the figure of four cases of 'ague' in the years 1771-1774, with three of those occurring in November and December, throws even greater doubt on the synonymity of the two diseases.

There can be no certainty about the diagnosis of malaria until the appropriate parasites have been found. Thus it cannot advance the argument that ague was, or was not always, malaria by examining the contemporary clinical records.

Nevertheless as they are of considerable interest and are not generally available, they are included in the appendices.

#### Summary

The hospital records of the Royal Infirmary, Edinburgh

and the Kelso Dispensary are examined over a period of 15 years from 1770 at a time when ague was said to be dying out. Attention is paid to admissions of patients having diagnostic labels which seem to indicate the willingness of the patients to come into hospital. There are very few diagnostic records which might indicate that children were chronic malaria carriers. The admission figures for ague and intermitting fevers are given and related to one another. The monthly incidence of both is noted. It is not apparent that these figures confirm the synonymy of 'ague and intermittent fevers' with 'malaria' for the seasonal incidence is wrong. It is therefore probable that there were acute fevers of unspecified origin recurring occasionally in epidemic form. The possibility of ague being synonymous with influenza is considered.

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## CHAPTER 11

Ague, the farm labourers disease. Possible vectors and differential diagnosis.

### Ague

It is apparent that the word 'ague' covered a wide variety of acute illnesses. There were not only 'agues', but also 'epidemic agues'. The latter differed in their mortality rates, response to treatment, geographical limits and, possibly, symptomatology from the 'marshland agues'. There was 'ague of the breasts'. There were agues which would respond to Fowler's Solution but not to 'bark'. There were those agues which afflicted townspeople but not the country folk. Even the typhus in Ireland was referred to as ague.

The ague reported in the Statistical Account of Scotland was largely a disease of the farm labourers. It is difficult to be sure how serious it was, although evidently it had a low mortality rate. However at least in England it was so common that an opening gambit of conversation might be 'Have you had your ague yet this year?'.

It is not possible to be sure why some patients with ague were admitted to hospital. In Scotland there were not large numbers of hospital beds available in those days. Yet in some years at Kelso a fifth of those admitted

had ague or intermittent fever. It might have been that they were admitted for the convenience of having them looked after. This is rather improbable if one reflects not only on the diffidence some people had about entering hospital even 50 years ago, but also on the frequent comments about the impropriety of visiting the very sick in their homes. Perhaps it was that those who went into hospital would receive adequate treatment there, whereas at home that was neither available nor affordable. Certainly Peruvian Bark had been prescribed in Scotland in the second half of the century and it is possible that patients could obtain it without a prescription. However neither of these options would have been used by the Abernyte farm workers and their families.

It has already been argued that most cases of reported ague were not, and could not have been, malaria. Therefore it is desirable to suggest a differential diagnosis for this apparently occupational disease. It must also be noted that although the parish ministers, the reporters for the Statistical Account, were not trained as doctors and had no facilities, not even a thermometer, for checking their observations, yet those who wrote text-books or popular medical encyclopaediae made a distinction between ague and various other diseases. For example ague was distinguishable from those illnesses which had clamant signs such as dysentery or whooping cough. It was also distinguished from those which had skin rashes such as smallpox and measles.



The major difference between the living conditions and circumstances of the farm labourers from the rest of the community was that the former were constantly in close relationship with a variety of animals, and were for much of the century working in countryside conditions in which the ground was in need of adequate drainage. It is not apparent that the latter disadvantage had any relation with any disease.

However it is also noteworthy that ague was not reported from the Highlands. In fact the parishes where its presence was noted were largely those in which the agricultural methods may be assumed to have been greatly improved in relation to other parts of the country. Such benefits not only involved improved housing standards and better crop returns, they also included a great increase in the numbers of animals on the farms, and the possibility of retaining them throughout the year.

The distinction between the farm labourers and other members of the community may thus have been the close concern of the former with possible animal vectors. However it must always be remembered that the term 'ague' covered a number of illnesses and it is most likely that at least some of those were associated with occupations other than farming and that the condition common to all was the overcrowding in the inadequate houses. Under such circumstances influenza at least would spread readily. (1) It is also important to observe that ague was said to have started in Scotland at the end of the seventeenth century

and died out a hundred years thereafter. It was known in England before, and remained prevalent after that period.

The animals with which the farmers were closely associated were cows, horses, swine, goats, dogs and hens although the latter were seldom mentioned. There were also rabbits, and a variety of insects which included fleas, lice, acarids and mosquitoes.

### Mosquitoes

The role played by mosquitoes has been discussed already. It is possible that changes have taken place in the last two centuries not only in regard to the part played by *A.m.atroparvus* but also by *A.m.messeae*. It is possible that the former used to breed in fresh water in inland districts. *A.m.messeae* did so and if in those days it had lived inside houses then it is more likely that malaria existed in Scotland, although the matter of the correct temperatures is a stumbling block. Under those circumstances it might have died out, as ague did, with the exodus of farm animals from the neighbourhood of human dwellings and also because of the increasing number of the animals. However it is to be observed that in summer the cattle lived outside on the meagre pastures, not in nor near the labourers' cottages. Furthermore such ecological changes would not explain the fact that the disease died out in Scotland 80 years before doing so in England. Even if one considers that there might have been some genetic change in the parasites it is extremely improbable that such a change would have affected one

country and not the other.

### Animal vectors

Of the other animal vectors with which farm labourers in particular come into contact cattle, pigs and goats are the most likely carriers of disease. There can be no doubt that there were rats and mice, (2) and the presence of acarids and pediculi were frequently remarked. (3) However the only diseases likely to be spread by the latter, and which would satisfy the essential criterion of a low mortality rate are 'louse-borne relapsing fever' and 'trench fever'.

### Relapsing fever

This is a disease which does not have a high mortality rate although it is probably higher at 3% - 5% than that described for ague in the eighteenth century. It does have a fleeting rash, which is so short-lived that it might not have been observed and recorded. It does not usually have an intermitting fever, and as a complication often does have a facial paralysis. For both the latter reasons it is an improbable alternative diagnosis although it must remain a possibility. Facial palsy would certainly have been noted if it had occurred commonly.

### Trench fever

This illness is probably caused by *Rickettsia quintana* which has been transferred to man by the body louse. It is reported that it caused nearly a million incidents amongst allied troops in the 1914-18 war. (4) It is



characterised by an intermittent pyrexia with a sudden onset. It manifests regular periodicity and sometimes lasts for several weeks. The mortality rate is practically nil. However it is also characterised in many instances by a subsequent neurasthenia. Its presence is certainly a possibility under the circumstances under review, and although its spread would not necessarily be confined to farm labourers and their families, at least it would have been more common amongst the poorer sections of the population rather than the well-to-do.

### Tularaemia

This disease may be transmitted by small rodents, e.g. rabbits. Mention has been made before of the remarkable numbers of rabbits in the countryside. Not only were they 'bred' on the links at Barrie (5), but it is recorded that at Dowally 125 dozen were killed annually (6), and at Stromness 36,000 were killed in one year. (7) It is curious to note in passing that Cambournac and Hill reported that *A.m.atroparvus* preferred feeding on rabbits to human beings. (8) Nevertheless this characteristic does not make any allowance for the problem of temperatures suitable for plasmodial development. Thus one may not argue that a plethora of rabbits rendered conditions suitable either for malaria to become indigenous or, having done so, to die out.

Tularaemia is a mild disease with a low mortality rate. It is believed to be transmitted very readily by the respiratory tract. Thus the overcrowding would readily provide conditions ideal for its spread.

Although the causative organism, *B.tularensis*, was only discovered 60 years ago, there are those who consider that this mild though frequently recurring infection is widespread and only thought to be uncommon because it is uncommonly sought.(9) It is characterised by a syndrome very like that of influenza, with headache, joint pains, fever and sweating.

Finally there are the farmyard animals, cattle, goats, sheep and pigs. Some of these may transmit Q.fever.

### Q.fever

This little known disease was first described by Derrick in Queensland. (10) It is spread to man from infected sheep, cattle and goats, and possibly by the bites of ticks. It is also transmitted to man by milk. It is characterised by a fever which often becomes intermittent, and may continue for three or four weeks. It has a low mortality rate, but if it becomes chronic it has a poor prognosis associated with various involvements of the cardio-vascular system. (11)

Bedson particularly remarked that it was a disease of agricultural communities. (12) He also noted that another feature was the explosive nature of some of the outbreaks. Strangely, there seems to be a preponderance of adult male victims and very few children seem to be involved. However both these characteristics may be associated with the present day habit of having male farm workers on the modern intensive and scientifically run farms in Australia,

a circumstance which would not have applied to the farm towns of the eighteenth century in Scotland. The fact that it may run a prolonged course would agree with the occasional prolonged stay in hospital of a patient with ague.

### Brucellosis

Of the animals with which the farm labourers would have come into contact, all of them have at one time been associated with the spread of this disease. It was first observed in Malta where soldiers had been drinking goat's milk. It is presently associated with handling cattle in Great Britain where steps are being taken to eradicate it. As for pigs, Dalrymple-Champneys states, 'A single case of Br.Suis infection, contracted in Eire has been reported'.(13) In France sheep and goats are involved and in Denmark, though not to so great an extent, swine are a source of infection.

Although milk was not widely available for the farming community, yet in the eighteenth century it is far more probable that much of the milk production used by human beings would have been consumed in the country areas because of the grave difficulty of transporting it to the towns. Besides most people drank ale. It was only when the winter foodstuffs were grown in some profusion that cattle were kept in the towns for dairy purposes. The disease however is also contracted by handling dejecta from infected cattle and thus might have been a disease of farm labourers even though they did not drink much milk.



Brucellosis is a mild but debilitating and chronic infection. If it was commonly found in cattle this would explain the folklore story about the billy-goat accompanying the herds. It would not however explain the lack of comment about 'dropping the calves'. (14) This was noted in England, (15) but only in one record of cattle droving from Scotland. (16)

It could be supposed that the incidence of the disease would increase in the spring time when the ill-nurtured cattle could find more food and would recommence milk production. However it cannot explain why the disease died out at a time when cattle husbandry had improved, and particularly dairy farming was increasing. Possibly with better husbandry there were many fewer persons employed on the land. Many of those who had worked there previously went to those towns where the new industries were starting concomitantly with the improved communication systems towards the end of the century.

Whether or not brucellosis was the main form of ague, it seems most probable that in consideration of its widespread incidence in cattle in modern times that it would have been present two centuries ago. If it had been present, certainly it would have been passed on to those who came into close contact with the beasts, just as to-day it is, or until recently was, a considerable hazard for the veterinary profession.

## Influenza

For several reasons it appears probable that this was one of the major varieties of 'ague'. There are several points in favour of that supposition and some against. Ague was a disease occurring in spring time and thus disrupting the sowing programme in Scotland. As a general rule influenza is a disease of the spring and autumn months, and not of the summer and mid-winter ones. Influenza is a disease most easily spread in close living communities. The cottages of the poorer class would meet this condition. Influenza usually has a low mortality rate and does not run a long course. However it does not usually leave its victims ready to start work as soon as the fever has left them. Nor in general is the fever intermittent. Both these factors may be overlooked, firstly because of the necessity of the men going out to work as soon as possible, and secondly because there was no means of measuring the type and duration of the fever. Furthermore the parish ministers who reported the presence of ague in the Statistical Account would probably have got their knowledge of this 'ague' from such books as Buchan's Domestic Medicine. In that, he was probably describing the East Anglian 'ague' which probably was 'malaria'. Probably Scottish parish recorders were not able to distinguish between the various aguish illnesses.

Apparently the term 'influenza' was not used until the end of the eighteenth century. It is possible that then and thereafter the new term was used to describe that

'ague' which was then called 'influenza'. Hence the former term died out. This is however an unconvincing argument. The parish recorders made their statements on the existence of the disease by observation amongst their parishioners, not as a result of studying hospital admission records. More cogent is the argument that if 'ague' was synonymous with 'influenza' it is most unlikely that it would never have appeared in, and been reported from, the Highlands. Because of the sparser population it would have spread less easily, but its recorded absence makes influenza a less likely alternative, invariably, for the ague of other areas.

### Conclusions

Of the six diseases considered it seems most probable that brucellosis would more readily agree with all the known circumstances. Supposing it was largely transmitted by cattle, the fact that cattle in the Highlands were largely beef cattle and would not have been handled very greatly would support the fact that ague was unknown there. It was known largely in those areas in which animal husbandry had flourished and had even turned to dairy herding. Furthermore it is probable that as it has been so widespread in modern times, it may have been as widespread in those days. However this does not explain why it died out at the end of the century.

'Q'fever is at least a possibility but may be too severe to be the equivalent of eighteenth century ague.



Tularaemia, trench fever and relapsing fever are all possibilities and could have had their influence diminish with the coincidentally improving housing conditions. Perhaps influenza is a more probable differential diagnosis. What is even more probable is that, as has so often been observed, ague was any acute fever, and all of these six illnesses may have played their part.

However unless the habits of the anophelene mosquitoes have changed in the last two centuries, in Scotland, and unless the facts reported about the housing conditions of human beings and their animals are wrongly interpreted, it appears extremely improbable that 'ague' should invariably be synonymous with 'malaria'.

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## CHAPTER 12

### Summary and conclusions

1. Contemporary records declare that many persons in coastal and inland parishes on the east of Scotland became ill with agues and intermitting fevers each year during the eighteenth century.
2. Those who did so were invariably from the labouring or artisan class.
3. Diverse causes were suggested. The commonest one was said to be swamp miasmata.
4. Contemporary medical writers gave descriptions of agues and intermitting fevers. The essential features were a cold fit, hot fit and sweating. These fevers were intermittent or at least remittent. They followed a tertian, quartan or quotidian pattern. There was no concomitant skin rash. The mortality rate was minimal.
5. Sometimes these agues were epidemic, and distinctions were made between vernal and autumnal epidemics. The mortality rate in epidemic agues was often high.
6. It is evident that ague, as implied by the derivation of the word, was any acute fever which had the limitations mentioned.
7. The term 'malaria' was introduced into England in mid-eighteenth century. It was the Italian name for



a fever associated with the miasmata from the Pontine marsh area south of Rome.

8. This fever corresponded to the agues and intermitting fevers of the English Fen and Essex marsh districts. Thus in common parlance malaria became synonymous with those terms. This synonymity was also applied in Scotland. Hence the agues of Scotland have been termed malaria by modern writers.
9. In order that malaria shall become indigenous there must be a series of incoming infected human carriers, a sufficiency of female *Anopheles* mosquitoes and suitable temperatures for the life-cycle of the parasite.
10. The malaria which was indigenous in Great Britain must have been 'vivax malaria' caused by *Plasmodium vivax*.
11. The only mosquito concerned in Great Britain with the spread of vivax malaria is *Anopheles maculipennis atroparvus*. That, and improbably but possibly *A.m.messeae*, might have been vectors in Scotland in the eighteenth century.
12. The former mosquito lives inside habitations, is not a total hibernator, breeds in saline and not fresh water and is preferentially zoophilic.
13. *A.m.atroparvus* is found in Scotland in the present day. There is no reason to suppose it was not

present in the eighteenth century.

14. The plasmodial life cycle may take 53 days to complete at a temperature not less than  $59^{\circ}\text{F}$ .
15. This minimal temperature is essential for at least two hours after the mosquito has fed on plasmodial infected blood. Anophelene mosquitoes usually feed at dusk and throughout the hours of darkness.
16. Temperature recordings at Leith in the summers of 1826 and 1827 show that  $60^{\circ}\text{F}$  was never reached in the hours of darkness. In 21 years in Edinburgh, 1945 - 1966, the temperature remained at  $60^{\circ}\text{F}$  two hours after sunset on only 68 occasions. In 14 years at Leuchars, 1956 - 1969, there were only 20 nights on which the temperature never dropped below  $60^{\circ}\text{F}$ .
17. The warm air of continental anti-cyclones penetrates to East Anglia and South-east England making the ambient temperatures there suitable for the development of indigenous malaria. A monthly mean temperature of  $60^{\circ}\text{F}$  for two consecutive months commonly occurs in England, but never in Scotland.
18. Outside temperatures in Scotland have not altered significantly in the last two centuries.
19. Housing conditions for farm workers in Scotland in the eighteenth century were not such as to allow the temperatures in summer during the hours of darkness

to be raised to the critical level.

20. Animals sharing a room with humans are unlikely by their presence to have raised the temperatures, except in summer, and possibly not even then, to the critical level. Their presence in the houses would have diverted the mosquitoes away from the human inhabitants.
21. Farm animals lived outside in summer which is the only season during which temperatures could possibly have been suitable.
22. Ague was said to have appeared in Scotland at the beginning of the eighteenth century and to have died out at the end of this period. These years coincide with the start of large scale cattle herding. Increased numbers were made possible by better farming methods. Cattle were separated from the farmyard precincts and were gradually displaced in favour of sheep.
23. Thus the zoophilism of mosquitoes could not have been satisfied before the century began. Nevertheless no ague was reported. The change in cattle farming could have influenced the dying out of the disease.
24. Ague did not disappear from the English marshlands until the twentieth century.
25. These districts may have been more suitable for mosquito breeding, and the habitations more suitable



- for plasmodial development than the Scottish counterparts. The factors influencing these circumstances are the greater width of saline breeding areas, and the higher ambient temperatures in England.
26. There is no evidence pointing to the spread of ague from the source of an incoming carrier. The reverse is true in England.
27. It is inconceivable that cinchona products played any significant part in the treatment and dying out of ague in Scotland, if ague was malaria. Cinchona was neither widely available nor pure.
28. Hospital admission records and clinical notes indicate that the terms ague and intermitting fever covered a large variety of acute illnesses, and not one specific entity. The monthly figures for new admissions of these illnesses cannot support the theory that they were malarial fevers, neither can the clinical notes and periods of stay in hospital support this.
29. It is possible that ague which appeared to be a disease of farm labourers might have been associated with animal husbandry. Thus brucellosis is a possible synonym for ague.
30. In different parts of Europe brucellosis is carried by pigs, goats and cattle. Since the causative organism has become recognisable an insignificant number of incidents in Great Britain have been traced

to goats and pigs. They may however have been carriers in this country 200 years ago. Beef and, later, dairy cattle and pigs, were the animals in the ague areas; beef cattle and goats in those areas alleged not to have had ague.

31. Tularaemia, Q fever, louse-borne typhus and relapsing fever are all possible alternative diagnoses.
32. It is most probable that an influenzal-like illness recurred frequently in spring and autumn seasons. However it would almost certainly have spread to the Highlands and West Coast where agues were not recorded. Nevertheless contemporary reports on such areas may have been less precise than those on more populous areas.
33. Agues and intermittent fevers were mild though incapacitating acute fevers. They appear to have a relationship with farming communities. They may have died out not as a result of land drainage but as a result of improved housing conditions, general well-being, and possibly different animal husbandry methods.
34. The temperatures in Scotland in the eighteenth century were under no circumstances suitable for the development of *P.vivax*.
35. Malaria could not have been indigenous in Scotland and should not be invariably synonymous with ague.

## APPENDICES

In view of the doubt that has been cast on the synonymy of 'malaria' with 'ague', 'intermitting fever', 'tertian', 'quartan' and 'quotidian' fever, any contemporary clinical records which reflect on this matter are especially valuable.

Some of these have been transcribed from textbooks. Others have been found, perchance, in libraries and private collections. These are quoted in extenso, not only because they throw some light on the problem, but also because they are of interest and are not readily available to many persons.

It is ever more apparent that the terms 'ague' and 'intermitting fever' described a variety of acute fevers and not one particular entity.

<u>APPENDIX I</u>	Sydenham, T. (1695)
<u>APPENDIX II</u>	Elliotson, J. (1846)
<u>APPENDIX III</u>	Gregory, J. (1771)
<u>APPENDIX IV</u>	Monro, A. (1766)
<u>APPENDIX V</u>	Unknown Dalkeith Apothecary (1733)



APPENDIX I

Sydenham, T. (1695) Complete method of curing all diseases; and description of their symptoms. Abridged and translated out of the original Latin.  
ff 13. 1st Edition London.

Sydenham in his chapter on epidemic diseases wrote of intermittent fevers:

'During the first days of the disease especially in autumn there is a remission rather than an intermission ... Furthermore we must remark that all epidemics are referable to one of two classes. They are either vernal or autumnal. Even when they originate in some other period of the year they must be referred to one of these divisions, spring or autumn to whichever they are nearest to as the case may be. Hence in using the words spring and autumn I am not speaking absolutely and by the card so that I do not mean the precise times of their respective equinoxes. Of the epidemics that show themselves in spring they begin as soon as January and reach their height about the 24th of March. They disappear by midsummer. To this class belong measles so do the spring tertians. These last although they may set in as late perhaps as February nevertheless disappear as midsummer

approaches. The autumnal intermittents set in and waxed prematurely for instance in the month of July when they do not at once put on the intermittent character which is particularly the case with the spring ones and when they so closely simulate the character of continued fever that without the nicest examination and comparison you cannot discriminate between the one and the other. In the year 1661 the autumnal intermittents which during the last few years had been gaining ground broke out afresh about the beginning of July. They gathered strength daily and in the month of August they were doing fearful mischief. In many places the mortality was excessive and whole families fell victims. The form was an ill-conditioned tertian. The symptoms that accompanied the present tertian differed from those of the tertian intermittents of other years chiefly in the following particulars. The paroxysm was severe. The tongue of the patient blacker and drier. The apyretic intervals were less defined; the prostration of strength was greater. The appetite was more affected. The fits had a greater tendency to repeat themselves. In one word the symptoms were formidable and the disease in general was deadly beyond the degree of an intermittent. If it attacked old men or cachectic subjects or patients who had been weakened by bleeding or other evacuations it was not got rid of within two or three months.' Later he wrote, 'All agues begin with shiverings and rigors succeeded by heat and terminated by sweats. In each of the first two paroxysms the cold and the hot the patient

has a strong desire to vomit. He is thirsty; has a dry tongue etc. These symptoms decline in proportion as the sweats come on. When these have broken out copiously the fit seems to have gone off and he that was just sick has become a healthy man. Sooner or later however the paroxysm repeats its attack ... I observe that the spring intermittents are neither long nor dangerous and they are always beneficial. A patient shall be both old and weak and that to any amount. He shall have been tampered with by the officious and pernicious interference of the most ignorant of practitioners, yet, providing that foul means have not been used, he shall escape death. I have seen however spring tertians so maltreated by undue blood-letting by undue purging and by unsuitable regimen that they have spun out their existence to the period of the autumnal ones and then as the time of the year is diametrically opposed to the genius of the disease in question it annihilates it at once. Never yet during this disease has it been my fortune to observe those formidable symptoms which come in the wake of the autumnal intermittents. I mean by these the deadly inflammation of the tonsils; the hardened belly of the dropsical swellings. Autumnal intermittents are very different. I must observe that whatsoever be the age or temperament of the patient with a quartanague if ever in his whole previous life no matter how long back he has suffered from it before a second attack will give him but little trouble. After a few fits it will go off of its own accord. This is worth knowing! In regard to the



treatment of spring agues I regard that they should always be left to themselves and not meddled with. No one that I know of has ever died of one.'

APPENDIX II

Elliotson, J. (1846). Principles and Practice of Medicine. Edited by Rogers, N. and Lee, A.C. ff 263. 2nd Edition London.

In this textbook Elliotson not only wrote his own observations but in addition quoted several other authors.

Elliotson wrote about intermittent fevers: 'Sometimes the term is applied especially in the plural number to all febrile diseases including primary eruptive and acute local inflammatory fevers.' He too talks about the cold and hot stages: 'and in the course of an hour or two perspiration breaks out when the hot stage vanishes ... The ague, the simplest and commonest of these diseases is not uncommon in the cold weather of our spring months. During the cold stage the constriction of the skin is so great that it becomes rough and in common language is called goose skin or cutis anserae. Such is the shrinking with this event that rings which had previously fitted fell off. There is a sense of creeping and shuddering over the skin, the hairs of which stand on end and this state is called horri pilatio.' He wrote about the hot stage: 'That state which is vulgarly called fever now takes place. If the disease remit altogether it is

called ague from the French 'aigue'. But the common people limit the word fever to the hot or hot and sweating stages and denominate only the cold stage ague. So that it is common to hear one of the lower orders saying that he had got ague and fever.' 'There are occasionally incidental symptoms such as tetanus, convulsions, fainting, violent delirium and the appearance of petechiae on the skin.'

'The paroxysm is usually over in 18 hours. It is a rare occurrence for it to last longer than that period.' However he quotes an unnamed author who states also that 'he saw a paroxysm which lasted only one minute. How the stages were divided I do not know!'

'There was one case in which the vertical half of the body suffered an ague. During the cold fit the other half becomes convulsed. Still more singular, the same half was not always similarly affected, but the symptoms changed sides.' He went on to write about the nature and length of the paroxysms: 'As a general rule the paroxysms become later and later as they become milder. It is very common at last for the paroxysm to show itself only a little at a certain time of the day, or there is only a little sweating or a little chilling. There is no general rule, for patients with ague may have only a little chilliness with great depression of spirits. They will cry, yawn, stretch and often be even a little silly and have a number of odd feelings. This state of things is well known by



the lower orders as the dumb or dead ague. The duration of ague is various. It may be ephemeral consisting of one paroxysm or it may last for many years, at least it did so before we could cure it so effectually as we now can do (1846). Ague affects all ages. It is seen in young children at the breast, and I have had under my care a man of about eighty years of age. It is said to affect children even before they are born. In Doctor Russell's History of Aleppo there is an account of a woman who had a tertian ague. This woman was with child and she shook every other day. The child within her she felt shaking regularly on the day on which she was disposed to be quiet. She shook for example on Monday and Wednesday and the child shook on Tuesday and Thursday. So that she had one tertian and the child had another. If it had not been for this adversity she could not have ascertained that the child had an ague, nor could the doctors. It further proves that the child had a different ague from the mother, inasmuch as the Peruvian Bark was given to the mother and that it cured both her and the child. As the child was so much younger I suppose that the Bark had more effect on it for it was cured one paroxysm before the mother.'

Of complications and effects he says that 'In hot weather the abdominal viscera are the more severely affected and ague is likewise very frequently attended with bilious vomiting, and purging and even by jaundice and dysentery. After death in the intermittents we often find congestion of the liver and of the abdomen. The

mucous surface of the alimentary canal is likewise in a state of great congestion.'

Elliotson quotes Bancroft as writing that he 'ascribes agues of the spring to the previous autumn because he has seen persons seized with ague after they have returned to England after being in a warmer climate where they had been exposed to miasmata and they had experienced agues before it could have arisen at home. It is certainly very common for harvesters who have worked in aguish districts in England where they have been exposed to the exhalations in autumn not to be affected until the east wind blows the following spring.'

Writing of prognosis he said 'An autumnal ague does not yield so readily as a vernal ague. The latter yields so easily that it often ceases spontaneously after a few paroxysms as the father of medicine said, 'after the seventh accession'.'

APPENDIX III

Gregory, J. (1771) Manuscript records from the Archives of the Royal Infirmary of Edinburgh.

Dr John Gregory wrote clinical notes on 48 people whom he admitted to the Royal Infirmary of Edinburgh between November 1771 and December 1772. Of this number none was diagnosed as having ague. One had a quotidian fever and several others a variety of fevers, none of which could have been malaria. However in those months covered by the manuscript there were only two cases of intermittent fever and two of ague admitted to the entire hospital.

'Thomas Franby. Quotidian Fever, aet 27, ad, 12 December 1772. (He) was seized last night with coldness and shivering wh. was succeeded by heat and sweat headache and thirst appetite impaired belly natural had a return of paroxysm after 6 p.m. since its first attack the last fit continued till morning and he got little or no rest in the interval is well imputes his complaint to cold Capt.Sol.F.E. hor 4.v. and sepr 0 hr ad 6.

'13th Dec. P.80 took the sol wh vomited him once gave a loose stool last night and one this morning had no coldness nor sweating fit only a slight degree of heat



Rep. Sol F.E. w.a.

'14th Sol did not vomit him but gave 3 stools had  
no return of febrile parox. 15th free from complaint.  
16th Quite well dismissed cured.'

APPENDIX IV

Munro, A. (1766) Manuscript clinical notes.

The three records following have been found in the Edinburgh City Library in the second of two volumes, the first of which is missing.

In none has a particular diagnosis been subscribed. All three have some relationship with ague.

'Mary Geddes age 27. Last September she had a tertian ague about a month. It then became quotidian and continued so for 5 weeks after which it had been removed by the use of emetic and bark. Soon after the ague was cured a leg and thigh began to swell considerably, which continued for one week. She has had pain in the thigh ever since, but last Tuesday she was seized at eight in the morning with coldness and shivering. This was followed by heat and a profuse sweat, but in the upper part of her body and not below the umbilicus. The same symptoms occurred on 21st, 23rd and 26th. After the hot fit and sweat she had severe pain in her head for 2 hours longer. On intermediate days she has pain in her side. Appetite good ... no thirst ... belly bound. Feb 27th Hot fit but no preceding cold fit. During the day she had two or three returns of the hot fit and sweating. Feb 28th. Vomit operated well. March 1st.

Pains in head and with hot fits and sweat. To have Electuary Febrifuge. Mar 2nd. No fit though one was expected. 4 Mar. She complained of giddiness. 5 Mar. had hot fit but about the time of it had a wandering pain in her breast with a sensation of suffocation and vertigo. She was given, every now and then, emetics and febrifuge and was better, but still had headaches and vertigo until Mar. 26th when she had further cold fits again and on the next day. On Mar. 30 she had a cough all night. Apr. 1st she had a cough all night which brought back her headache ... just now it is easier but has brought back the burning heat of her lower extremities. Apr. 3rd given bark every three hours. Tenesmus and abdominal pain after taking the bark. Apr. 7th has had only four doses of bark and has sweated ever since yesterday. Apr. 8th free of all aguish symptoms. Apr. 14th cold fit and sweating this morning. Apr. 15th sweating was interrupted yesterday. Apr. 25th discharged still with aguish fits daily. Has had bark daily. To ordinary physicians.'

This was certainly not straightforward malaria. She may have had a thrombo-phlebitis with a possible pulmonary embolism on March 30th. The pain in her side might have been due to a perisplenitis.

'Jan. 6th 1766. Sarah Walker aged 30, has ever since the 2nd inst. been attacked in the morning with lassitude, heaviness and a general chilliness of her whole



body without trembling and succeeded by heat and terminating in sweat. On the even days they seem to recur with more violence. In the night she has a troublesome cough. She has regular menses and stools. Almost a year ago she got free of an ague which had hung on her for two years and had appeared in the different form of quotidian, tertian and quartan. 10 Jan. complains of chilliness in her bones. But pulse natural. Repeat emetic (ipecacuanha). 12 Jan. Should have Tartar emetic at night. 13 Jan. Skin moist and clammy but without any fluid sweat. Repeat emetic. 15 Jan. Cold fit and rigor: slept, but has not sweated any. 20 Jan. Dismissed cured.'

Certainly this was an acute fever and thus could qualify as an ague. However it does not read like the description of a person who is having a relapse of malaria.

'Joseph Drummond aged 37. After labouring at hard work in October last in low ground in Yorkshire upon the banks of the River and eating a gt. quantity of apples and drinking plentifully of skimmed milk and water was seized with aguish paroxysms very irregular in their return, till he took some medicine when they ceased until the end of December after which the ague returned in the form of a quartan. The fits generally come on about noon, the cold fit holding about two hours. There is no

sweat after the hot fit being lately much exposed to cold. During the last week has been much troubled with a cough which made his breast sore. He thinks he has found some relief in taking garlic, and also thinks his belly swells in the evening. This morning had a vomit which worked well. A pain in his back generally precedes a fit. Let him drink freely in the hot fit, and if he sweats let it be encouraged by some weak sack, whey and Julap every hour. Feb. 20. Sweat did not come on until 6 or 7 in the evening. Has another complaint pain in the back when he stoops. Give Tartar emetic and Pulv. Ipecac.

'Feb 22 purged yesterday. 25. Cough easier. Took his vomit this morning. Did not feel any preceding symptoms of his paroxysm. If it comes let him promote the sweating of the hot fit. 26th. Sweated all night after hot fit. 27. Without complaint. 28. Has the cold and common preceding symptoms of a fit. March 1 and 2 well to-day. 3. sharp pain in back. 4. Cold fit succeeded by hot fit and plentiful sweating. Pulse 78. 5. without complaint. 6. He has pain in his back previous to a fit. 7. had cold fit and sweat. 8. no complaint. 9. round his back all night which still continues. Coldness in his feet sickness and thirst. 10. coldness but not so violent as formerly sweating was scanty. Chief complaint nausea and thirst. Tartar emetic. 11. vomit worked well and loose stools this morning. Headache when he coughs. 12. no sleep last night being affected with asthmatic fits when he has great

difficulty in breathing. 13. further sweating. Three loose stools. 14. sweating yesterday in afternoon. Pulse 96. Still has headache and difficulty in breathing. Delirious in the last night. Bled from nostril. 19th March scarce can swallow any liquid Pulse 104. 21 March died last night at 4 o'clock.

Once more this does not appear to have been typical malaria. Perhaps it was a case of typhoid. Or possibly it might have been miliary tuberculosis.

So of these three cases, all of which had aguish histories, none suffered a disease similar to that which one would expect in a relapse of malaria.



APPENDIX V

Records of an unnamed Dalkeith Apothecary. (1733)

Quite by chance this manuscript was found in the National Library of Scotland. It contains comments on several scientific conundrums, comments on the latest medical books and records of ill patients the author dealt with in Dalkeith in 1733. There is no name attached to the record and all that is known so far is that the author was an apothecary in Dalkeith at the time. So far this record can only be identified as the 'Dalkeith Apothecary's Manuscript'.

Notes on ague

The apothecary wrote some notes on, amongst other illnesses, ague. 'Tertian agues make some young people grow I understand ... I find that Mr Erskine says it is always useless to give the bark in agues whilst the urine continues red. It would also seem very improper to purge at the beginning of agues at least for the first three or four fits any more than in the beginning of ordinary fevers, unless there appears a considerable apparatus for humours in primae viae.'

The apothecary wrote the following notes and records in his notebook:

'I have found in aguish cases accompanied with a considerable swelling of the legs that under the use of pills with extract gentian and camomile each three drachms t.d.s. Peruvian bark q.s. the swelling of the legs in a few days disappeared and the strength much recovered even though at the same time the patient had considerable drought and redness of urine so that the patient came afterwards to have his fits gradually easier, his drought less his appetite greater and urine more temperate till at length they wholly disappeared. However I observed that upon intermitting the use of these pills the fitts very soon returned only the patient did not sweat so much unless it were well provoked with a strong white posset. I also observed that a few spoonfuls of tinctura sacra would put away the fitt in the declension of an ague so that at least the sweating was not sensible but the crisis seemed to be by urine in great plenty. I found it somewhat dangerous in the use of the foregoing pills to take a dose of them near the time of the fitt in which case they much disturbed, occasioned great anxiety and nervous symptoms. It was usual to drink after each dose of the pills a draught of some rich Spanish wine as Madera, Lisbon etcetera or medicated bitter wine.'

#### Effects of various foods

'N.B. it seems to be a vulgar error to submit the use of the summer foods as cherries, strawberries gooseberries and currants at least moderately in an ague especially when the drought and heat is considerable and the patient

has a strong inclination after them. However turnips and small beer and several other things seem bad and I have found them hurtful taken in any quantity. The skin of the turnip seems safest. In the time and beginning of the cold fitt, I found some harm by drinking large quantity of tea and whey or other small liquors and although the drought seemed to require it, it seems advisable to drink very sparingly at that time. But nature when in the greatest struggle may not be overloaded with fluids. However a certain proportion of warm posset is then absolutely necessary to cure the gruing. It is very well known that astringent draughts do service in the ague, and particularly claret wine drunk in the apurexy as I found myself and am told by several others who have tried especially strong claret.'

#### The Apothecary's own illness

'I found in the beginning of my ague most terrible nervous symptoms about the time when the sweat was beginning to break out or before its breaking out which afterwards disappeared with the use of these pills with bark. Possibly the best immediate cure of ease in these symptoms would have been from some strong anti-hysteric juleps. The fitts were accompanied sometimes with a vast palpitation of the heart, difficulty in breathing, a sense of coldness, sometimes as if the body had been all frozen or turned rigid, which seemed according to Hippocrates the worst symptom of all. This rigor was accompanied with a suppresion of urine, and had a constant



raving with it and a sense of almost immediate death. It was very frightful and the opinion of many is that the best nervous medicines are the ordinary bitter aromatics given with bark which have their immediate operation on the peristaltic motion of the gutts. About the end of the hot fitts of my ague I always felt an excessive heat and a sense of burning under the sternum which I thought hardly ever went away perfectly, and often when the whole body seemed pretty cool and easy in the sweat, this burning heat still remained in that place. Perhaps there was some small inflammation in the stomach or medias-tinum. I had a great drought and delighted particularly in eating the red currants made into a tart.'

He goes on, 'I once myself fell into a violent night sweating attended with strong obstruction of the hypochondriac, a cough and many nervous symptoms from which a dangerous ague which at first had well nigh killed me quickly relieved me by throwing out all into the glands of the cutis, where I unluckily stopped it. For by continuance in the ague it might have been wholly carried off by sweating and had already wholly cleaned the viscera. I was also unwise enough about the end of my ague thereby Doctor Clarke's advice used the hora sacra which carried all off by urine and hindered the discharge of sweat. However by this I learn that I have given considerable relief to a dangerous and troublesome strangury I had in the beginning, namely by a spoonful or more of this tincture given before the fitt, or of compound

tincture of rhubarb or something else less heating than either of them.'

#### The illness of the Moffat apprentice

The apothecary was called to 'a case of a nervous fever at Moffat in the month of September 1733. A young lad one of Mr Milligan's apprentices had been troubled for some time past with an ague to such a degree as to bring him very low and dispirited. He was of a dark brown complexion inclining to the atrobilarious constitution. He had been for some time past been subject to hypochondriacal disorders and had taken it into his head to stand out the ague as long as possible without taking the cortex. In this condition he fell into a fever. When I was called to him some time after he had a continual hiccup and difficulty in breathing which threatened almost sudden death. I caused him to be tried with a toast and a glass of wine instead of the thin diet he used. A Bolus of Valerian and camphor and at length by degrees the hiccup disappeared, but afterwards when the difficulty of breathing seemed to threaten much I advised a moderate phlebotomy and moved all his symptoms. Afterwards he seemed to recover slowly though I came away before he was perfectly well.'

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